POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Nobody Home!

MAYBE THIS IS NOT THE PROPER caption for this picture, in fact we admit it is a bit slangy but it seemed to fit in with the conditions it portrays and since we could not think of a better one, here it is.

This building looks like a garage but, really, it is a power plant—a steam turbine generating station, if you please, and if you look closely you will see, just inside of the open door, the end of the turbo-generator. If you were there and walked inside you would see the whole unit, a thousand kilowatt unit and perhaps a few other things, but that is about all. If you were curious about anything and looked around for an operator or engineer to explain it to you, "you'd be plumb out of luck." For there isn't any operator or engineer, not even a watchman; in fact, there isn't a soul in the place—there's nobody home.

Now, don't jump to the conclusion that the plant is shut down; it isn't, it is operating full blast, supplying not only electric power but also exhaust steam whenever load conditions demand it.

To a certain extent, it is an automatic station but more correctly it should be considered as a remote controlled plant, for its operation is directed and supervised from another "main" power plant some distance away. The complete description of this interesting development will be found on page 684 of this issue but here we want to comment on the use of telephone relays in this plant.

Many years ago we pointed out that telephone engineers had developed relay practice to a very high degree of perfection and that the power plant designer could learn a great deal from the telephone engineer regarding the use of relays. The power engineer uses relays but they are clumsy, sluggish affairs compared to those the telephone engineer uses. It is gratifying and encouraging, therefore, to note a liberal and intelligent use of telephone relays in this installation; indeed, the application of this equipment is largely responsible for its outstanding success.

The fact that this plant operates entirely unattended need not necessarily concern power plant operators. It will be some time before all power plant operators have been displaced by automatic equipment. There are other more important things which the power plant operator should think about these days and one of these things is the question of vacuum tubes.

Up to the present time the vacuum tube has been only an incident in his home life. Occasionally, his radio set may have gone dead and that meant a trip to the corner drug store to have the tubes tested, but beyond that, tubes were of no particular consequence in his life. He never encountered them in his work.

The picture is changing, however. Nowadays, occasionally we come across devices in power plants in which we find electron tubes. It may be only a battery charger but there it is—a tube glowing brightly, doing work which was once done by a small motor generator set. Again, we find tubes in metering devices, in automatic recorders and sometimes in voltage regulators. On large systems we find them on the electrical end, controlling relays, generating "carrier" current. In the unattended plant we have just discussed they are used in protecting the control wiring from high potential surges.

These tubes, however, are small fry compared to some in use. Consider, for example, the tube installation described on page 677 which furnishes all the 25 cycle current required by a large industrial plant. In this instance tubes actually replaced an engine generating set. An unusual case, perhaps, but it shows the trend. In our August issue, it may be recalled, we described an installation of tubes which furnished all the exciting current for a 15,000 kv-a. synchronous condenser.

There are a lot of these things going on. Slowly, step by step, more and more applications of the electron tube are being made in the power plant. It seems to us that if we had charge of a power plant we would make it our business to know something about electron tubes regardless of whether there was an immediate use for them or not.

WITH THE EDITORS

Court Decisions Build Confidence

GROSSLY ARBITRARY, unreasonable and capricious—those were the adjectives which Federal District Judge William C. Coleman in Baltimore used to describe the Public Utility Act passed in the last session of Congress when he ruled the Act invalid in its entirety. This of course was not a Supreme Court decision but at least it is an indication of the opinion held by the judiciary in high courts of the country.

This Wheeler-Rayburn Bill, it will be remembered, was tossed back and forth between the Senate and House for several months before final passage. Lobbying for the bill were representatives of the administration determined to have incorporated in the bill a provision popularly known as the death clause which placed rigid restriction on the conduct of electric utility holding companies. Opposed to the bill were representatives of holding companies and committees of investors interested in companies directly or indirectly affected by the bill. The intensity of the controversy has seldom been equalled in the legislative halls of the country.

Vast capital interests were at stake and it was not surprising that almost immediate litigation was started to test the constitutionalty of the measure. The first case to be ruled on by a federal judge was instituted by the American States Public Service Co. as plaintiff to determine whether the company should register with the Security and Exchange Commission as required under the Utilities Act. The judge's instructions were to disregard the provisions of this act. The case will undoubtedly be taken to the U. S. Supreme Court as early as possible.

On every hand, not only the privately owned public utilities but many other lines of private business enterprises have been harassed by government acts passed through the Congress and many state legislatures as reform or security measures to such an extent that corporations are in doubt as to how to conduct many phases of business and keep within the law. Much of the recent legislation which has been a deterring element to business recovery is believed to be unconstitutional and is being tried in the courts throughout the country. Courts, of necessity, must move slowly and the expense of these trials must be borne in major portion by individuals or corporations directly affected by the law. It is little wonder that the public in general, for the time being, endures unjust laws, even those that they think are unconstitutional in the hope that changes can eventually be effected without personal expense. It is only when industries or corporations with substantial financial backing take up the legal battle that newly enacted laws can be promptly tried out in the high courts and authoritative decisions secured upon which industry can depend.

This decision in Judge Coleman's court fortunately has come within a few months after enactment of the law and before it has become fully effective, and it is to be hoped that final ruling by the Supreme Court will be obtained soon. Restoration of employment, increase in industrial activity, extension of business and recovery conditions in general must start with confidence in the minds of those undertaking the projects that their investments will be secure and that their efforts will be justly rewarded. This confidence is growing, as indicated by a gradual increase in industrial activity, due in no small measure to the indicated assurances that the Supreme Court of the United States will compel adherence to the provisions of the Constitution regardless of the acts of the legislative and executive branches of the Government.

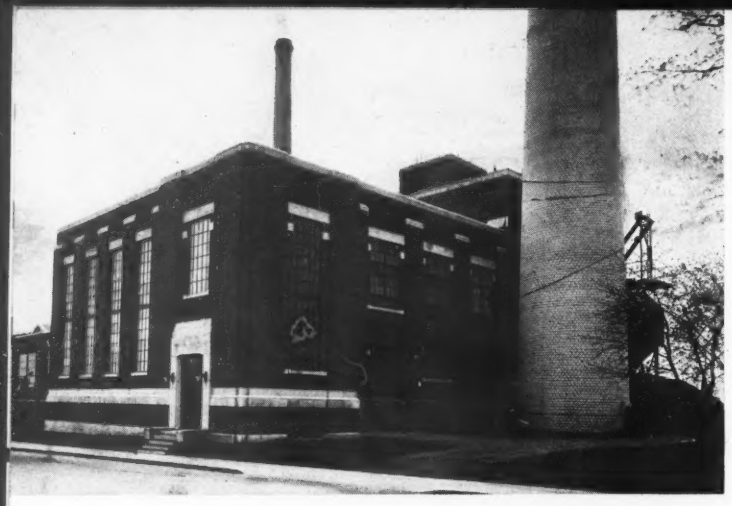
Scientists, Engineers, Salesmen Industry Builders

TO OBTAIN scientific data on any subject which can be used in the development of industry, is the recognized function of an industrial research scientist. To the engineer falls the duty of putting scientific data to work for man. Science must precede engineering, but the gap in time between the discovery and proof of a scientific principle, and its application in practical service is a measure usually of public acceptance rather than a failure of engineers to visualize the field of usefulness of scientific discoveries. Public acceptance is the product of salesmanship.

These three activities—research, engineering and selling—are so interwoven in the development of industry that it is difficult to separate one from the other. The scientist must sell his discovery to the engineer, the engineer must sell his product to the industry. Neither scientists nor engineers are salesmen in the sense that they are specialists in sales psychology but each one must depend upon the services of the other to succeed completely in putting scientific discoveries to work in industry.

The electric motor was a scientific toy for many years before its industrial application was discovered. Somewhat similar delays were experienced by the gyroscope, and notably the steam turbine. Today, however, thanks to a better understanding of science by engineers and engineering by salesmen, industry is not so slow in taking up with new scientific principles as in years past. The principles of X-ray, for example, were not long in finding their way into industrial application, in fact industry was ready to use X-rays in some applications before research and pioneering experiments had been completed to the satisfaction of engineers. Right now the principles of electronics are being applied in industry to such an extent that revolutionary changes are taking place. Synthetic materials in the form of alloys or chemical compounds are being formed to possess almost any physical or chemical characteristics the engineer may specify.

The significance of this early acceptance of new principles is the fact that industry is in search of new channels through which men may work to a higher standard of living. To the power plant engineer comes the warning that the equipment which will be installed in his modernized plant will use many principles uncommon to the old plant and his position will be jeopardized if he has not mastered these principles in time to meet the occasion.



Shelby, O., increases boiler pressure to 250 lb. and adds two 509 hp. boilers and a 1500 kw. turbine in a new plant designed by The Froehlich & Emery Eng. Co. Cooling tower used for circulating water.

Ohio Municipality Increases Generating Capacity

SHELBY has one of, if not the, oldest municipal plants in the state of Ohio, dating back to 1890. On May 18 of that year, less than a month after the state legislature passed a bill authorizing villages to construct and operate "Electric Light Works," the village voted in favor of a $15,000 bond issue. The present plant site was purchased for $200 and early in December the plant was put into service, billing to customers being on the basis of the number of 16 candle power lamps installed.

Additions were made in 1900, 1914, 1919 and 1920 in accordance with the growing load, the last two including two 150 lb. water tube boilers and a 1000-kw. non-condensing General Electric turbine which are still retained in the old section of the new plant. The non-condensing turbine was used to supply heating steam to two nearby schools, an ice plant and a sales book company. In 1927 a 1000-kw. Elliott automatic extraction type condensing turbine with a Foster-Wheeler condenser and auxiliaries were added, the extraction line supplying steam formerly supplied from non-condensing operation. This unit was built in anticipation of later raising the steam pressure so that it would fit in with the equipment in a modernized plant. The new unit had been in but a short while when the bad sleet storm of 1928 practically wrecked the distribution system and interrupted service for several weeks.

In 1931 a movement to sell to a utility company was defeated and a bond issue of $80,000 voted to rebuild the plant shortly before the present Superintendent of Public Utilities, E. W. Quiggle, was appointed. The Froehlich & Emery Engineering Co. of Toledo, O., was retained as consulting engineer and put in charge of the design. Modernization of the plant, of course, involved not only the use of modern and efficient equipment but provision for future development and expansion and the work had to be carried on while maintaining full service. The new plant was therefore built in stages. The first step was the building, adjacent to the north side of the old plant, of a new boiler room, a brick stack, an ash hopper and coal storage. In the north bay of this new building was installed a new 509 hp., 250 lb. pressure Stirling boiler and in the adjoining bay, the auxiliaries.

With this boiler in service, supplying steam for the 1000-kw. unit rebuilt for the higher pressure, two old boilers were removed and the new building extended south into the old structure to give an additional bay for the installation of a second new boiler. The new turbine room was then added east of the boiler room and a 1500-kw. turbine installed. This section was financed from a P.W.A. loan and grant, one of the first to be authorized. The addition of this new turbine together with the rebuilt 1000-kw. unit gives a total generating capacity of 2500 kw., not including the 1000-kw. low pressure non-condensing unit which was retained for standby. The old

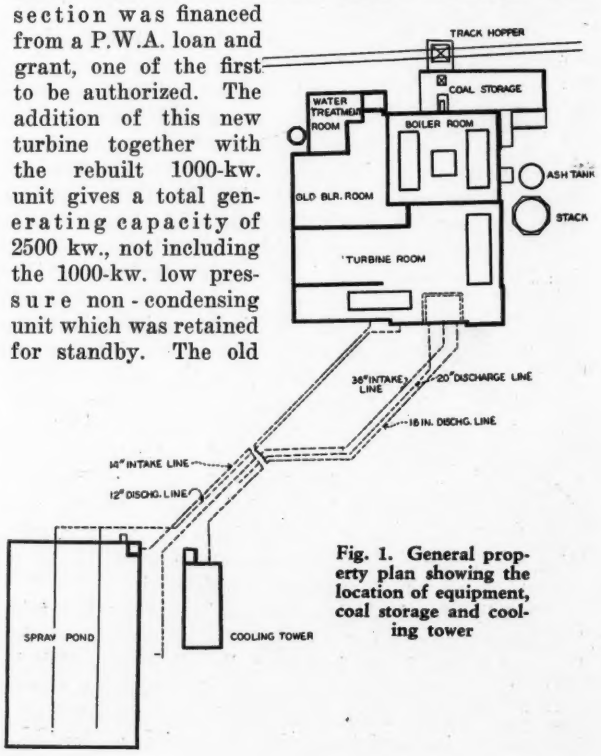


Fig. 1. General property plan showing the location of equipment, coal storage and cooling tower

engine generator units were removed when the new boiler room was built and space is available in the new building for the installation of another turbine unit, plans for which are already under way.

An exterior view of the station from the northeast corner is shown in the headpiece. The old engine room is visible at the left, the new boiler room at the right of the photograph and a portion of the ash hopper and coal storage yard can be seen just beyond the stack. The new building, which measures 108 by 64 ft., is built of tapestry brick, trimmed with artificial stone and the turbine room interior finished in salt glazed brick. In the turbine room basement is located the condenser and auxiliaries, in the boiler room basement the coal and ash hoists, air compressors, forced draft fans, heater and soft water pumps.

New boilers are 509-hp., 250-lb. Stirlings with fusion welded drums, each with 720-sq. ft. of Elesco superheater surface designed to give 200 deg. F. superheat at a steam load of 22,500 lb. per hr. Fuel is fired by six retort, 123.5 sq. ft. projected grate area, Taylor underfeed stokers with HeleShaw drive to give flexible control at all loads. Boiler settings are of radically new design and incorporate the first of the Detrick sectionally supported, insulated walls made up of 9 in. of refractory with an outside coat of plastic insulation to give a heat loss equivalent to a 21 in. solid refractory wall. The settings were constructed by Geo. Allen & Sons and the furnace volume is 2775 cu. ft., a conservative figure based on a design able to handle Ohio coal successfully at a continuous rating of 200 and a maximum rating of 250 per cent for periods of 4 hr.

Two Sturtevant 19,000-c.f.m. at 6-in. of water and 1724-r.p.m. forced draft fans driven by G.E. 1760/1175-r.p.m., 440-v. motors are installed in the basement directly under the boilers they serve. By means of ducts these fans take their suction from the top of the boiler room, materially aiding ventilation and giving the boiler the advantage of reasonably warm air at all seasons. These fans, the stokers and boiler uptake dampers are under the control of a Bailey air operated combustion control system, the operating air for which is supplied from an Ingersoll-Rand type 30 two stage V-type compressor driven by a 5-hp., 1750-r.p.m. G.E. motor.

For control purposes, three panels are provided, one master and two individual. The master panel consists of a Consolidated-Ashcroft-Hancock indicating steam pressure gage, a Bailey recording steam pressure gage and a master selector valve for switching both boilers from automatic to manual control. Each individual panel consists of a Bailey five pointer draft gage, a Consolidated-Ashcroft-Hancock indicating steam pressure gage, a Bailey boiler meter with a steam temperature pen, a Bailey water level recorder and three selector valves, one each for manual adjustment of the stoker speed, boiler load and uptake damper position.

Boilers are equipped with Diamond soot blowers, Swartwout S.C. feedwater and excess pressure regulators, Reliance gage columns and glasses, Schutte & Koerting stop valves and Crosby safety valves. Steam leads from each boiler go to a main header in the basement and this in turn supplies an auxiliary header, both being sectionalized in such a manner by Lunkenheimer valves that any section can be isolated for maintenance work. This header, and the superheaters as well, are drained by Strong, Carlisle & Hammond traps. Both boilers are identical with the exception of the ash hoppers, one of which was supplied by Link-Belt, the other by Bartlett & Snow. Both of the hoppers have a capacity of 193 cu. ft. and are equipped with Beaumont-Birch cast iron pivoted water drain gates. The hoppers are made of copper steel and are lined with 4 in. of vitrified hard burned shale brick laid in cement mortar and are equipped with spray nozzle for quenching the ashes. Ash from the hoppers is dumped direct to an industrial car and elevated to an overhead ash hopper by a 2100-lb. Link-Belt skip hoist driven by an 8.7-hp., 1200-r.p.m., 440-v. Lincoln motor. Ashes are taken away by truck for use on the city streets.

Coal received by rail is handled by a complete C. O. Bartlett & Snow coal handling and storage system. Coal is fed from the track hopper by an apron feeder which delivers it to a bucket elevator-conveyor for delivery through division chutes to a coal bunker in the auxiliary bay between the two boilers. From the coal bunker it is drawn out by hand into a larry which weighs the coal and distributes it to the stoker hoppers. The bottom of the bunker is provided, also, with a rack and pinion slide gate through which coal is delivered by a chute to a storage pile on the outside of the building where it is stacked out by a drag scraper.

Coal is reclaimed from ground storage by a drag scraper which delivers it to a reclaiming hopper located above the apron feeder. The bottom of this hopper is closed by a rack and pinion slide gate when not in use. The design permits the installation of a coal crusher at the discharge end of the apron feeder, at some future date. This coal handling equipment will handle 35 t. per hr., either the nut and slack bituminous coal 2¼ in. and under, used at present, or run-of-mine when a crusher is installed between the apron feeder and the elevator-conveyor.

Track hopper has a top opening of 12 by 12 ft., covered by a steel grillage of 10 in. square openings. The apron feeder, feeding coal from the track hopper to the elevator, is a 30-in. standard Bartlett-Snow apron conveyor, inclined from the horizontal at an angle of about 16 deg., is about 23 ft. long between centers of the head and foot shafts and operates at a speed of 30 f.p.m. It is driven through a Falk totally enclosed, herringbone, gear reduction from a 3-hp., 1200-r.p.m. Westinghouse totally enclosed, squirrel cage induction motor.

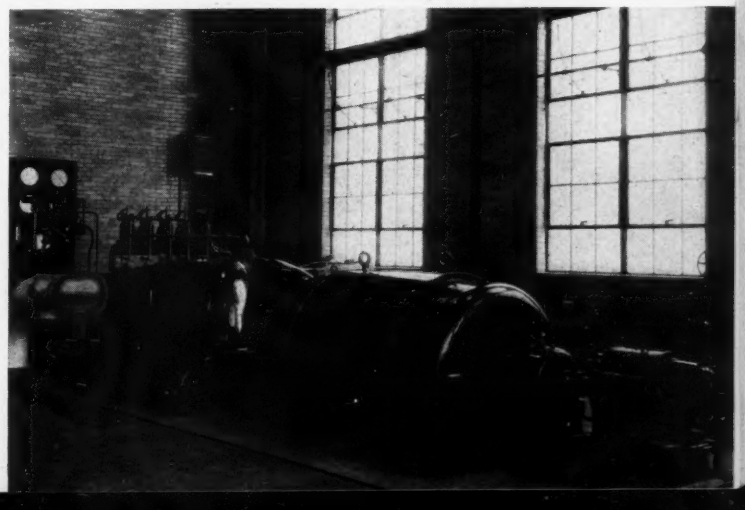


Fig. 2. The new Elliott 1500-kw. turbine

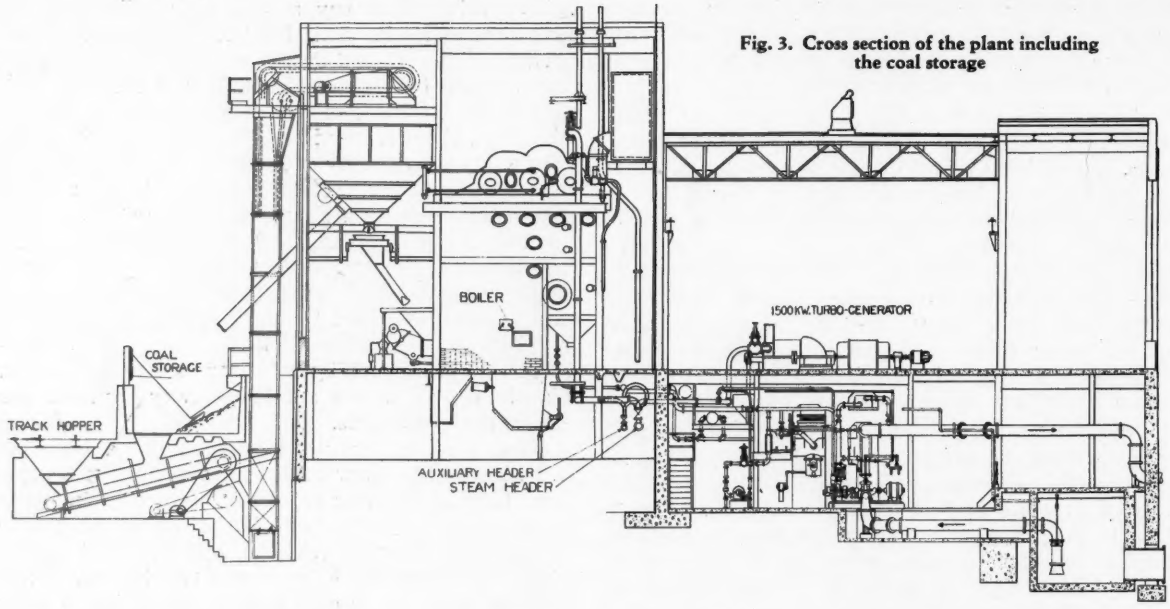


Fig. 3. Cross section of the plant including the coal storage

The elevator-conveyor is made in the form of an inverted L having a vertical elevator leg about 62 ft. high and a horizontal carrying and discharging leg of 18 ft. long. The working parts consist of a series of 14 by 18 by 7-in. steel buckets carried between two strands of steel bushed roller chain. It operates at a speed of 80 f.p.m. and is driven through a Falk totally enclosed, herringbone speed reducer by a 7½-hp., 900-r.p.m. totally enclosed Westinghouse squirrel cage induction motor arranged for starting directly across the line.

The coal bunker as furnished by Bartlett & Snow has a capacity of 75 t. of coal. It is made of 5/16 in. steel plate with bottom slopes of 45 and 61 deg., the valley being 40 deg. The bottom of the bunker is equipped with three undercut gates operated from the firing floor. The weigh larry is a 2000 lb. Bartlett-Snow type, operated from the firing floor by hand chain and wheel. It is equipped with Fairbanks scales and provided with a card punching device that records the weights.

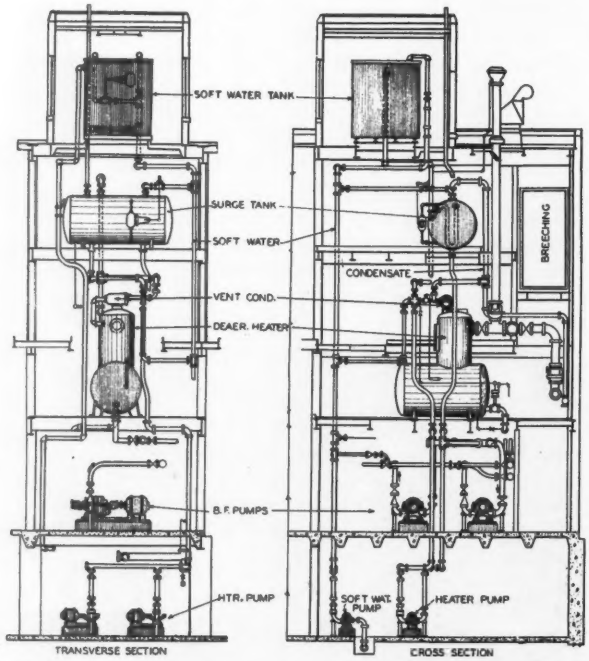


Fig. 3A. Cross and transverse sections through the auxiliary bay

Ground storage equipment is of the scraper bucket type with a handling capacity of 25 t. per hr. when operating on a haul of 50 ft. This is based on a scraper bucket capacity of 450 lb. of coal and a traveling speed both forward and backward of 270 f.p.m. The National Lambert double drum driving unit is driven through a silent chain by a Westinghouse 15 hp., 1200 r.p.m. motor. Control of the scraper is through two hand levers, one for each drum, banked in quadrant for remote manual control from the operator's station outside of the boiler house.

Water for boiler feed makeup and cooling tower makeup is pumped a short distance from the Blackfork of the Mohican River. This water is softened in a Cochrane cold process lime and soda ash softener with a capacity of 6000 g.p.h. The softener water is then filtered, and, that used for cooling purposes goes direct to a suction well in the turbine room basement. From this well the circulating pump takes its suction. Boiler feedwater goes from the filter to the soft water pumps to be elevated to the surge tank or soft water storage on the roof above the auxiliary bay.

Boiler auxiliaries are located in an auxiliary bay between the two boilers, longitudinal and cross sections of this bay being shown by the drawings. On the roof is a 2800 gal. soft water storage tank filled by two Ingersoll-Rand 100-g.p.m., 100-ft. head pumps driven at 1750-r.p.m. by 5-hp., 440-v. Westinghouse motors. These pumps take their suction from the Cochrane cold process treater and are controlled by a Fisher float control on the storage tank. Directly underneath is the surge tank receiving condensate return. This tank is maintained above a minimum level from the soft water tank above by a Fisher float control. From the surge tank water is delivered to

the Cochrane 75,000-lb. per hr. deaerating heater, through a 29-sq. ft. vent condenser, by two Ingersoll-Rand 225-g.p.m., 100-ft. head heater pumps driven by 10-hp., 1750-r.p.m. 440-v. Westinghouse motors. The pumps are used to give positive delivery when the heater pressure is above atmospheric. Two Ingersoll-Rand 225-g.p.m., 800-ft. head boiler feed pumps take their suction from the deaerating heater. These pumps are located on the firing floor, one is driven by a 75-hp., 440-v., 1750-r.p.m. Westinghouse motor, the other by an Elliott 80-hp., 2200-r.p.m. turbine. Smolensky check valves and Lunkenheimer oilers are used on these pump units.

In the turbine room the new generating unit, furnished by Elliott, consists of a 225-lb., 600 deg. F. turbine driving a 1875-kv.a., 0.8-p.f., 3-ph., 60-cycle, 2400-v. generator at 3600 r.p.m. As shown by the flow diagram, this turbine is bled at two points. The high pressure bleed point, together with what auxiliary exhaust there may be, is used for feedheating in the deaerating heater and for the external heating system. The old turbine is fitted with an extraction pressure control but the new turbine is not, and, as, at full load, the stage pressure may run as high as 60 lb. ga., a pressure reducing and desuperheater station, operating automatically under a Bailey control, is provided. A pressure of from 3 to 5 lb. gage is maintained in the heating header which is drained by an Armstrong trap. When the extraction pressure drops below the desired value, the Bailey control opens to supply the deficiency through a reducing valve and desuperheater. Both the extracted steam and high pressure bypassed steam is metered by Bailey flow meters. The low pressure extraction point is used for feed-heating in an Elliott 104-sq. ft. closed heater which follows the steam jet condenser in the feed-water cycle.

The turbine is set over a C. H. Wheeler 1750-sq. ft. two pass welded shell condenser with a Wheeler two stage twin steam jet air pump and air leakage meter. Both the steam jet cooler and the extraction heater are drained back to the main condenser through Wheeler drainers. Duplicate Wheeler 60-g.p.m., 130-ft. head condensate pumps are installed, one driven at 1750-r.p.m. by a 440-v., 7½-hp. Westinghouse motor, the other by a 6-hp., 1750-r.p.m. General Electric turbine. The hotwell level is maintained constant by a Fisher float control throttling the discharge from the hotwell pumps.

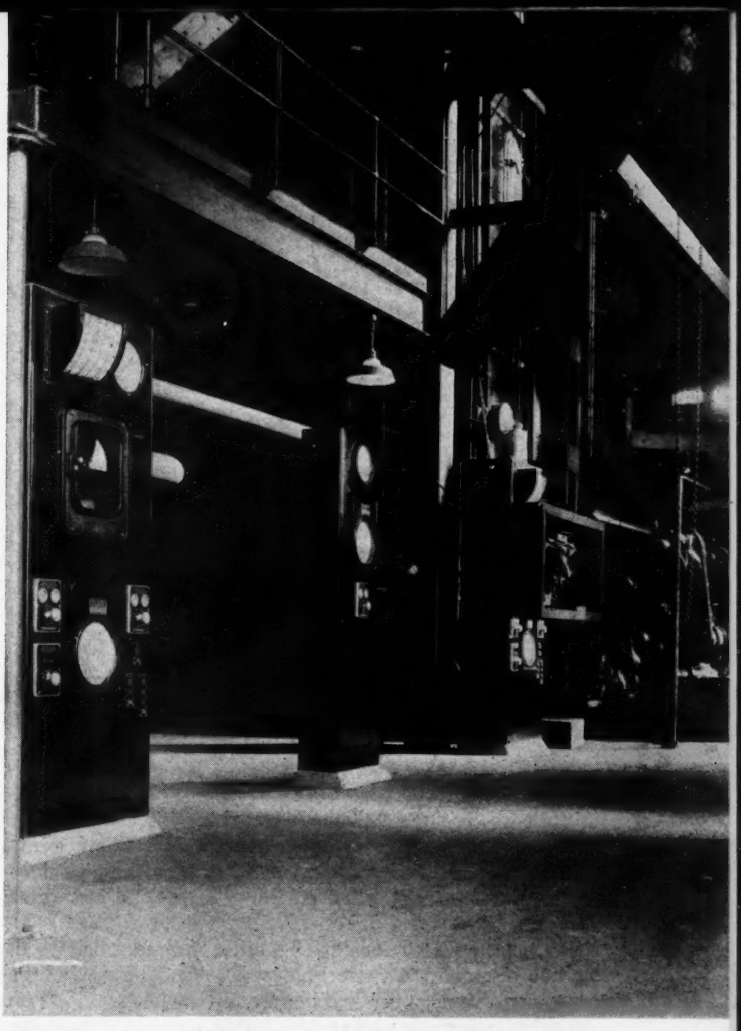


Fig. 5. One of the new high pressure Stirling boilers fired by Taylor stokers. The Bailey master control panel is at the extreme left

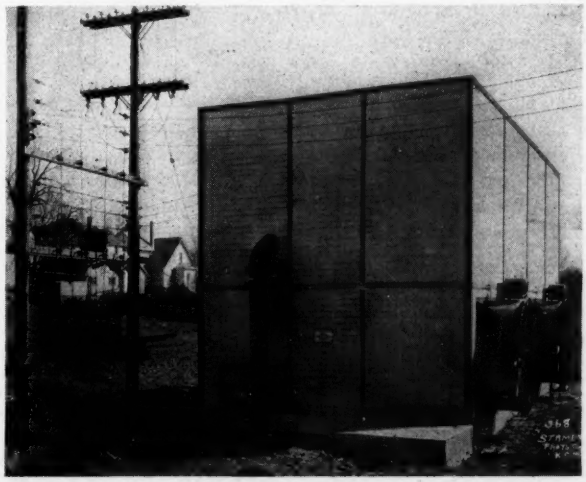


Fig. 4. The new Marley tower which cools the circulating water for the new turbine

One 2790-g.p.m., 53-ft. head De Laval circulating pump is installed. This unit is dual driven at 1170-r.p.m. by a Westinghouse 440-v., 1170-r.p.m., 50-hp. motor and a G.E. 45-hp., 3840-r.p.m. geared turbine. The turbine picks up the load automatically when the motor speed drops. This pump, which takes its suction from a well underneath the basement floor, is primed by an Elliott ejector. Cooling water for the General Electric generator air cooler is taken from the discharge of the pump through Elliott twin strainers and returned to the condenser discharge line.

The turbine panel for the new units consists of C-A-H pressure gages indicating the throttle pressure, first extraction pressure, second extraction pressure and condenser vacuum; a Bailey recording and integrating flow meter with a steam temperature recording pen; a Taylor barometer and Taylor mercury column. In addition there is a Biddle vibration tachometer on the turbine; C-A-H indicating thermometers on the bearings and C-A-H indicating pressure gages and Taylor indicating thermometers on the circulating water lines. Other auxiliaries include a Schutte & Koerting turbine throttle valve, C-A-H turbine relief valves with Swartwout exhaust heads on the roof,

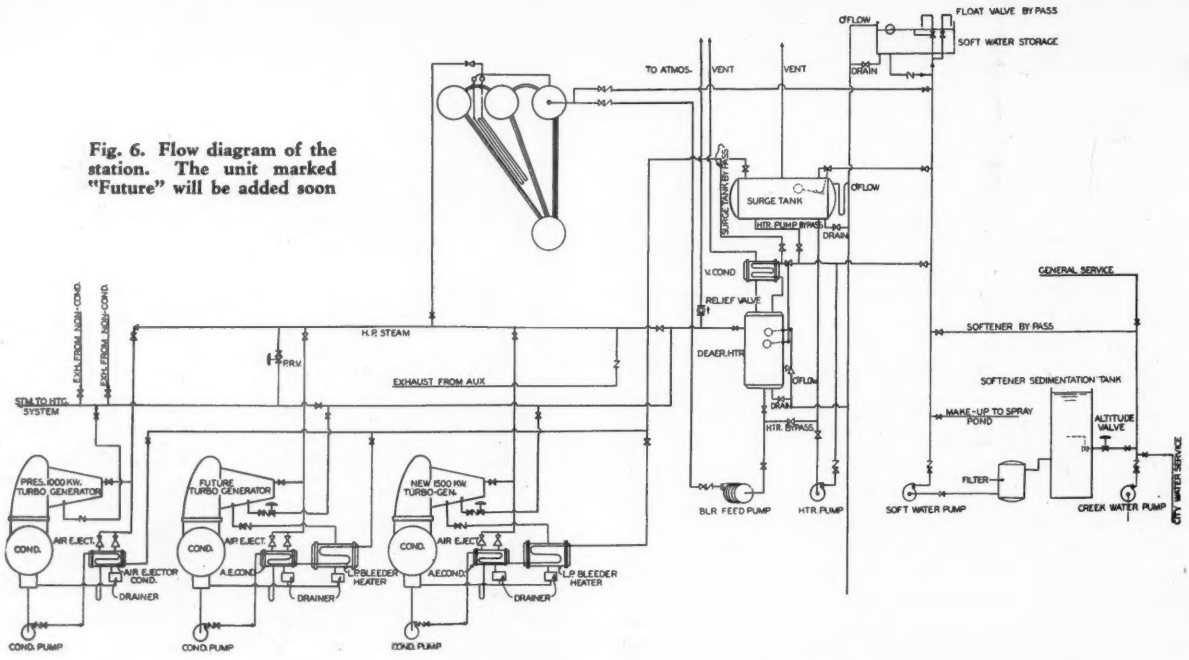


Fig. 6. Flow diagram of the station. The unit marked "Future" will be added soon

duplicate Schutte & Koerting turbine oil coolers with Elliott twin strainers; U.S. Rubber expansion joints on the condenser connections, Lunkenheimer valves and Chapman check valves on the circulating water lines.

Cooling water for the old units was supplied from a cooling pond across the street. The high windage loss entailing high makeup and complaints from nearby residents, made it advisable to supply the cooling water needs of the new unit from a cooling tower. For this purpose a Marley forced draft cooling tower designed to handle 2500 gal. through a cooling range of 15 deg. F. was selected. The tower, shown by Fig. 4, is of the forced draft type with four 96 in. propeller fans each with a capacity of 80,000 c.f.m. and driven by 10-hp., 1800-r.p.m., 440-v. Ideal motors.

A General Electric, steel panel control board with General Electric instruments, synchroscope and voltage regulators is provided. Each feeder is metered by integrating wattmeters and records kept of the total load and generator voltage. In accordance with modern practice, each unit is provided with its own voltage regulator, a Cutler-Hammer field rheostat being used with the new generator. Circuit breakers are all of the remote solenoid operated type. Control current is supplied by a 125-v., Electric Storage Battery Co. storage battery equipped with a General Electric 1½-kw., 1800-r.p.m. motor generator set for battery charging.

Fig. 7. Coal storage yard located between the railroad and boiler room

Other equipment installed includes: Type A safety switches made by the Electric Controller & Mfg. Co., used throughout; Swartwout rotary ball bearing ventilators on the roof; an Ingersoll-Rand 7 by 7-in. single stage air compressor driven by a G.E. 15-hp., 440-v., 1750-r.p.m. motor for general service; Modine unit heaters with the heating system drained by a Trane condensate receiver unit with the pump, driven by a Wagner 3-hp. motor, controlled by a Cutler-Hammer float switch; a portable Invincible vacuum cleaner; a Uniflow sump pump driven by a ¼-hp., 1725-r.p.m. single phase, 110-v., Master motor.

The plant has been a source of service to the community since the first and under able and competent management is showing a nice profit to the city even on the low rates, which range from 6 to 2 ct. per hr. for domestic and as low as 1.25 ct. per kw-hr. for industrial power. In an exhaustive analysis of the question of public vs. private ownership, E. W. Quiggle, Superintendent of Public Utilities, estimates the plant is saving the city $28,000 per year. In this analysis comparable private utility rates of surrounding communities are used and taxes are based only on the book value of the distribution system. The value of the plant has not been considered for Mr. Quiggle contends that due to bad cooling water conditions a utility could not afford to generate power locally but would bring it in over transmission lines, leaving only the distribution system to be taxed.

Boiler Operation and Furnace Explosions

By P. F. ROGERS

MORE WIDESPREAD USE of the explosive fuels, gas, oil and pulverized coal have reduced the number and severity of furnace explosions because operators are more familiar with their characteristics and now know how to deal with them safely. The old time flareout, so common with hand-fired furnaces of a generation ago, especially during the war, was also an explosion of a mild nature. The danger is present in all types of furnaces and the fireman should understand the causes and remedies in order to prevent damage to the furnace and injury to himself and others. Explosion or safety doors will usually protect the furnace but the fireman must protect himself from flame, hot coals and injury from the suddenly opened doors.

With hand firing the danger is greatest with old type furnaces designed for burning hard or low volatile coal. During the war and at present, since the wave of economy and "help local industries" sentiments brought on by the depression, the cheaper and usually higher volatile coals have been substituted. Firemen unfamiliar with the new coal and furnaces not designed for the liberation of such quantities of combustible gas combine to make a dangerous combination. Explosions may occur either when the door is first opened or shortly after it has shut.

Stoker Furnaces Usually Better Designed

With a good setting, air infiltration through the walls is small. With the new low grade fuel the fuel bed is often thick and the draft high trying to carry the load. Under these conditions the furnace is filled with highly combustible gas which has insufficient air to burn completely. When the door opens, air rushes in in great quantities due to the high draft and an explosion of more or less severity takes place blowing flame and coal out through the door. The same thing except for reversed conditions may happen when the door is opened and a few shovelfuls of fine coal are thrown on the fire. In this case the furnace fills up with air and the new coal fed on the incandescent fuel bed distills quickly. This rich gas mixing with the hot air causes an explosion.

The remedy in either case is better air control and a more nearly balanced draft in the furnace. A small forced draft blower in the ashpit will give the necessary draft through the fuel bed at small cost. It is well to remember that only a limited amount of coal can be burned by air forced through the fuel bed and that the additional air must be supplied to the top of the fire. Stoker fired furnaces also have their explosions but rather rarely because the furnaces are usually better designed, sudden fuel changes harder to make, and the air supply, under better control, introduced at the proper point and in such a way as to cause turbulence and prevent rich gas pockets.

Gas is by far the most dangerous of the fuels and for this reason is treated with respect even by the careless firemen. Natural gases are sometimes almost without smell, however, and this forms another danger, that of asphyxiation while cleaning or doing work when the boiler is down. This hazard is minimized for domestic service by mixing with other gas to give it a penetrating and obnoxious odor. When a boiler is shut down the damper should be left open so that gases will not collect and form a pocket which might be dangerous to workmen or which will explode when the furnace is lighted. When induced draft is used this fan should always be started first to thoroughly clean out explosive gas mixtures which might have accumulated while the boiler was shut down.

Pilot Lights

To a certain extent the same thing is true about oil and pulverized fuel. A leaky oil burner may drip on the hot refractories and distill off gases that collect in pockets and explode when the furnace is lighted. It is for this reason that it is bad practice to light an oil or pulverized coal fire from a wood or shavings fire in the furnace. Much of the early fuel might miss the flame and distill off slowly by radiant heat and then ignite with an explosion. Oil burners can be ignited with comparative ease and safety by means of a torch made of a swab of waste soaked in kerosene and tied to the end of a rod long enough to reach in the furnace in front of the burner. Even then a flare back should always be expected and it is well to have the head and eyes anywhere except in front of the peephole.

For pulverized coal a gas or oil-fired pilot light should be provided. These can be arranged to operate automatically and are often used on oil-fired furnaces as well. In one well known installation burning pulverized coal and gas intermittently in the same furnace the pilot light is constantly burned. In the larger pulverized coal plants the induced draft, forced draft and pulverizers are electrically interlocked so that they can be started only in the proper sequence and shut down in the reverse order. Usually these interlock systems are made so that they can be thrown off manually and the equipment started in any desired sequence for some unusual condition. It seems, however, that this defeats the very purpose for which the interlock was put on and that it should be arranged so that under no circumstances could the machines be started in other than their proper order.

After the boiler vents and drains are opened, the stack damper should be opened, or if already opened its position checked, and the induced draft fan started. Then light the pilot light, start the exhauster and then the pulverizer. In stopping, the pulverizer should be stopped first and the exhauster run until the coal is used up. Then shut down the exhauster and finally the induced draft fan. Interlocks can be arranged in any desired combination to meet local conditions and should be used to prevent accidents due to carelessness on the part of the operator or to unfamiliarity with the equipment.

Arrangement *of* Piping *for* Steam Engines

By THOMAS HALL, CONSULTING ENGINEER, ELLIOTT CO.

The following discussion answers two questions submitted by one of our readers and the practical importance of the points emphasized warrant close study. The questions are:

Why should an engineer be more cautious when cutting a high-speed compound engine onto a surface condenser than when cutting on a slow-speed compound?

With a surface condensing compound engine, what should the operator watch out for with sudden increase or decrease of load, such as occurs in lighting plants during sudden darkness? R. B. F.

IT IS TRUE that caution should be used when starting up a compound engine and putting it on the line. It is also true that there is danger from quick changes of load with a compound engine, that is, compared with a simple engine.

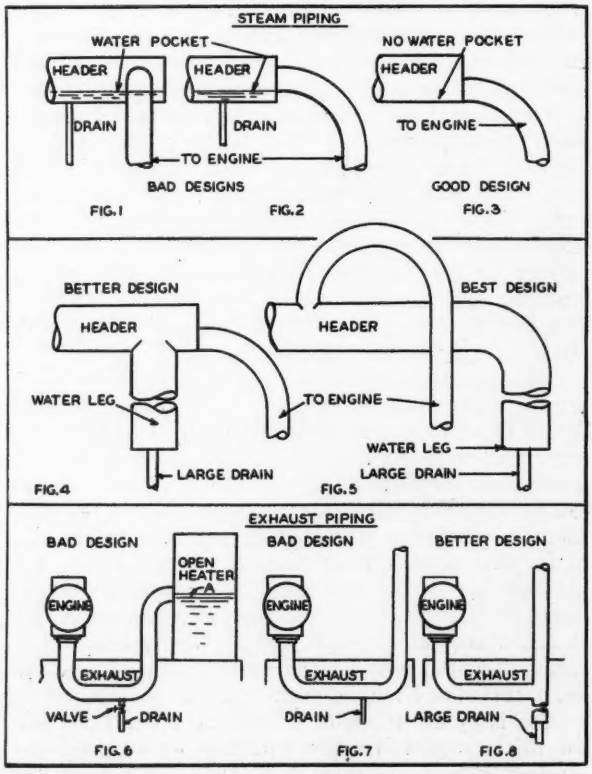
Perhaps the best reasons we can give are suggested by pockets in various parts of the piping where water can collect. The collecting of a volume of water when standing or when running on light loads and its sudden throwover into the cylinder on a quick change from light to heavy load may easily cause trouble. This is not greatly different from the case of a compound engine except that there are many more pockets in a compound engine in which water can collect due to steam leakage when standing idle or even when running on light load. If water collects when standing then there must be very good provisions for effective draining of all pockets on starting up.

Condensation may cause further collection of water on no load operation before load is built up, hence the necessary precautions. Such dangers require extreme precautions, especially if the steam header lines are not carefully designed to eliminate water. We are sure there is much more danger from a compound, whether condensing or non-condensing, than with a simple, single cylinder engine. We are not sure that there is more danger in this respect with a high speed compound than there is with a low speed compound assuming the piston speed to be the same, though we cannot say positively there is no difference. If there is any difference it should be slight.

There is little the operating engineer can do to avoid accidents during sudden changes of load assuming all drains and traps are working properly. It is rather the problem of the engineer who laid out the plant to see that his designs are such as will keep the system of piping and engines well drained. Many an operating engineer has been blamed for such accidents when it was not his fault, when the fault laid with the piping designer or the engine builder, usually the former. We do not mean to say the operating engineer is blameless, he, too, can cause trouble through possible lack of knowledge, neglect of duty or carelessness.

The question of piping is a vital one and is frequently not given sufficient attention. Let us consider the header arrangement shown, Fig. 1, a large header with a concentric smaller pipe leading off to the engine from the end and a drain from the bottom of the header some distance from the end. Such drains are too small and get clogged up or the trap fails to work. The danger of such a line is that it gets filled up to the bottom of the bend leading to the engine when running on light load, then when a sudden heavy load comes on, the water is swept over into the engine and causes a wreck.

In the first place, the bend to the engine should connect with an eccentric flange as in Fig. 3, as water is not likely to collect. The drain should be close to the end of header and preferably not less than 1½ in.



Figs. 1 to 8. Examples of good and bad steam and exhaust piping

pipe for engines of 200 kw. or over. This drain should preferably have two 1¼ in. traps rather than one 1½ in. size. It is unlikely that both will get out of order at the same time.

All steam piping and header lines should slope toward the engine and not toward the boiler as is sometimes done. The end of a header or line farthest from the boiler is always the worst and most likely to give trouble. In Fig. 1 a side opening leading to the engine is equally as bad as a line coming off the end of header, as in Fig. 2.

Figure 4 with a water leg is very good since such a water leg collects most of the water and provides a much better drain off. Expecting water to drain off where there is no water leg is like trying to pour water into a bottle, you need a funnel, the water leg forms a good funnel and also provides for some volume of water. You should always make sure your steam lines and cylinders are well drained before starting up.

Exhaust lines can cause trouble too if not properly installed and properly drained. A bad arrangement of exhaust is shown, Fig. 6. If for any reason the feed-water heater fills up to exhaust pipe inlet and overflows, it can get into the cylinder due to expansion within the cylinder below atmospheric pressure, when running at very light or no load. True there is a drain shown with a valve in it, but these get clogged up and such drains should not have a valve in them if it can be avoided. They should blow to the outside. Most drains are too small for safety.

Make sure drain pipes are not put in so they can suck up water into the cylinder under light or no load operation. In one case the cylinder drains run down through the floor and nearly to the surface of a creek. The creek rose and then froze over. Water was sucked up into the cylinder, wrecking the engine. Cylinder relief valves are a good thing but they are not sure proof against such accidents.

New Office Building Has No Windows

By E. J. BERLET*

COMPLETELY air conditioned, and with no windows whatsoever, the new three-story office building of the Hershey Chocolate Corp. in Hershey, Penna., will provide scientifically produced artificial working conditions for Hershey executives and office workers. Accurately controlled temperature, humidity, and modern lighting will make the occupants of the building entirely independent of daily variations in the weather; but, although the building's occupants will be oblivious of the weather outdoors, they will be apprised by an electric signalling system just what to expect when they go out.

Design of the building was developed by the company's engineers, D. Paul Witmer, who is in charge of construction, and A. Bowman Snavely, chief engineer. The air conditioning system, laid out with the cooperation of engineers of the York Ice Machinery Corp. which is installing the refrigerating and air conditioning equipment, will automatically supply air at the proper temperature and humidity for all seasons.

The windowless feature will give a distinct advantage in estimated 25 per cent lowered operating costs of the summer cooling and winter heating equipment.

Elements of the air conditioning system consist of a standard York refrigerating system rated at 135 t. of refrigeration capacity per day, located in the basement, and two separate air washing systems which serve conditioned air to the second and third floors respectively. These two systems will maintain interior conditions of 80 deg. F. dry bulb temperature with 65 deg. F. wet bulb in the summer, and 75 deg. F. dry bulb temperature with a 48 per cent relative humidity in the winter. A complete system of fans, with air ducts, grilles, and accessory equipment will insure circulation of conditioned air at the rate of 90,000 cu. ft. per min., with a constant supply of outside air introduced at all times to keep the air fresh.

The Electric Weather Man indicating outdoor weather conditions, consists of a small brass panel placed near the electric clock which is installed in each office, with three colored glass bull's eyes in the panel and a miniature electric light behind each. The colors are red, white, and green, so that seven different combinations have been adopted to indicate the outside weather. Thus white will indicate clear weather; white and green—cloudy; red—rain; red and green—sleet; green—snow; red and white—clear with temperatures below 10 deg. F.; and red, white, and green—clear with temperatures above 90 deg. F.

By a unique system of complete artificial lighting, the usual wide variation in the intensity of daylight will be avoided. The effect of actual daylight, with none of its accompanying eye-strain, has been achieved through the installation of special lighting fixtures which combine the most desirable features of both the Mazda and the mercury vapor lighting systems. The lighting will be almost completely indirect, and the fixtures are so installed that there will be maintained at the working level, on the desks, an intensity of 20 foot-candles, which is considered the best practice for modern office lighting.

"The reason for doing this," says Chief Engineer Snavely, "is to secure a combination which will tone down the orange and red in the Mazda light by introducing just the right softening effect with the violet and blue rays from the mercury vapor lamp. A combination of the two within the same fixture approaches daylight, and gives a far better effect than any single source of light could give. Within each of these combination fixtures there is one 750-watt Mazda lamp and one 300-watt mercury vapor lamp, making a total of 1050 watts per fixture."

Two separate power plants serve the lighting system as well as supplying power to drive the air conditioning equipment. Should the regular source of current fail while employees are at work, within a few seconds an automatic throw-over switch will establish electric current from an entirely separate source. In this event, the secondary source of supply will also furnish power to operate the motors which drive the ventilating fans of the air conditioning system, so that the building will never be without an adequate supply of fresh, conditioned air and light.

*York Ice Machinery Corp.

Combustion Control

Part XI. On and off stoker control. Thermostats, pressure switches, low water cut off, air and damper control. Interlocked or sequence damper and stoker control to prevent blow back. Pressure control of gas fired boilers.

SO FAR, this series of articles has considered equipment only in connection with boilers fired continuously, the function of the control apparatus being to vary the fuel and air supply with load so as to maintain an almost constant steam pressure. During recent years, however, the small stoker, burning from 1000 down to a few pounds of coal per hour, has been perfected and widely applied. These stokers are commonly made with motor drive, the motor, coal feed mechanism (usually a screw) gear box and forced draft fan being built as an integral unit. Their application extends from the domestic field up through apartment buildings, office buildings and small industrial plants with heating boilers of up to 200 or 250 hp.

Control used is commonly known as the "on-and-off" because the stoker operates at a fixed speed and is then stopped for an interval until conditions change sufficiently to require another period of operation. Some stokers have but one speed, others have a gear box with two or even three speeds. Fans are usually driven by V-belt and change of air volume supplied for a given screw speed may be varied by means of the pulley ratios and damper position.

For a given adjustment, therefore, the stoker screw and fan operate at a definite speed so proportioned as to give good combustion while the stoker is operating, the surplus heat stored in the system being depended upon to carry over the off periods. The control problem is to start and stop the unit in response to demand impulses. These demand impulses may be from a room thermostat, a steam pressure gage or hot water thermostat, depending upon the type of installation, and may be interlocked with safety devices such as a low water alarm or draft regulator. Although the problem is simple a satisfactory commercial control of this kind offers difficulties to the designer due to the wide range of application, the necessity for a relatively low price, the need for flexibility and, because the majority are installed where skilled engineers are not available and failure means a wait for a service man, the demand for absolute reliability without attention.

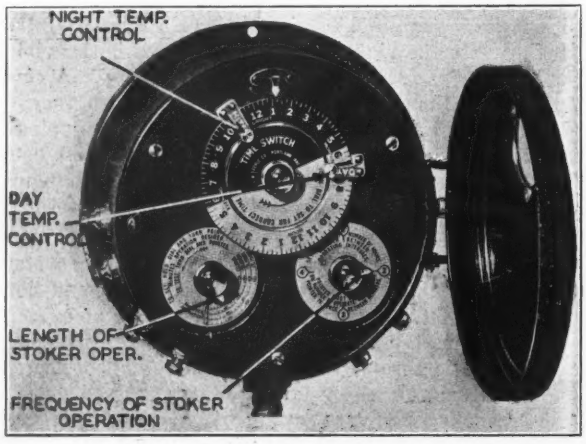


Fig. 1. The selective Synchrostat, a Teeple control as used on the Iron Fireman stoker. It automatically changes over from day to night control and fires the stoker periodically to keep the fire alive, irrespective of demands for heat

For heating installations the primary control is usually a room thermostat or hot water thermostat

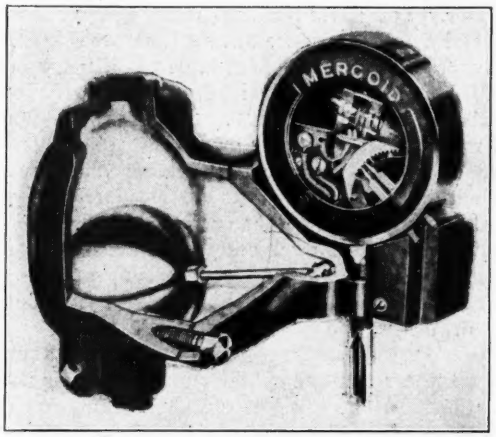


Fig. 2. A pressure control switch combined with a low water cutoff as made by The Mercoid Corp.

which turns the stoker off at a predetermined temperature and turns it on again after the temperature has dropped to some lower limit. These thermostats are usually of the bimetal strip or expansion type arranged to close and open electrical contacts. The contacts carry only a small current, being arranged to operate a relay which in turn starts the motor either direct or through a regular motor starter.

Inasmuch as heat losses during the night can be considerably reduced by reducing the room temperature, it is customary to arrange these devices so that the day temperature of say 70 deg. F. can be reduced to say 50 deg. during the night. This may be accomplished by a manual adjustment on the thermostat or automatically by using a dual thermostat—that is two instruments side by side, set for different temperatures, and switched in and out of the circuit by a switch driven by a small synchronous motor like a clock. This switch is usually adjustable so that the switching time may be changed at will. A switch of this kind incorporated in a more complete control is shown at the top of Fig. 1.

For hot water thermostats a number of designs more or less standard for temperature control work may be used and need not be described here. Their function is to open and close electrical contacts just as room thermostats do but the fact that they are immersed in water influences their external design. Some make use of the expansion properties of metals, some

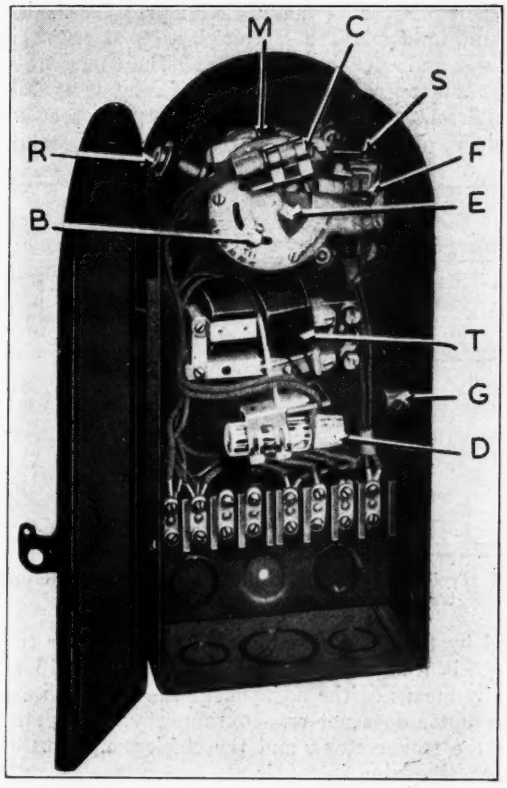


Fig. 3. Stokatherm Control of The Mercoid Corp. which refuels the fire, compensates for fuel variations and stops the stoker if the fire goes out

use bimetal strips and others use Bourdon or spiral tube elements as in the common recording thermometer.

Safety Devices

Single control of this kind answers the need for heat demands but offers no protection for the boiler to take care of the time lag between the boiler and room thermostat. This can conveniently be handled by a pressure limiting or temperature limiting device which cuts off the stoker before the danger point is reached. In dual control of this kind either instrument acting independently can stop the stoker but both must act together to start it. In very small installations the limiting device may be the uptake temperature but the pressure switch is more common. This switch may or may not be combined with a low water control as shown in Fig. 2. The pressure control consists of a Bourdon tube arranged with adjustable electrical contacts. The low water control is a float, which, when the water becomes dangerously low, opens the stoker drive circuit.

The stoker is thus under the control of from one to five separate conditions: room temperature; water temperature; steam pressure; gas temperature; low water. The arrangement of these control circuits will depend upon the needs of the installation. Thus in a system where steam is supplied for both space heating and hot water, the room thermostat and water thermostats would be placed in parallel so that either can start the stoker but they should be in series with the pressure switch and low water cutoff so that the stoker would respond to the demand for heat only if the boiler pressure and water level were satisfactory for safe operation.

Auxiliary hot water control keeps the water in the boiler heated to any desired temperature without interfering with the steam heating controls. When heat is not needed, the stoker operates only to supply hot water requirements. Normally the hot water regulator is set for a temperature below the steaming point so it is unnecessary to shut off the steam valve, an important point during spring and fall, when variable weather requires heat at irregular intervals.

Auxiliary hot water control could be added to a hot water heating installation, but it would be necessary to valve off the heating system during warm weather to prevent circulation. This might conveniently be done by a thermostatic motor controlled valve if conditions warrant the expense. Normally this condition may be handled satisfactorily by installing a switch in the control system to cut out the thermostat during the summer, at the same time placing the hot water regulator in direct control. This switch is then thrown to summer position when the valve is closed and the water in the boiler is kept at the desired water temperature throughout the summer. The same course may be followed for summer operation in installations regulated for heating purposes from steam pressure.

Refueling

With oil or gas fuel or even with stokers where the firing intervals are sufficiently frequent to keep the fire burning, such simple controls give automatic operation. In warm periods, however, heat may not be required for several hours or perhaps days and it is necessary to keep the fire alive. This may be done by operating the stoker automatically at definite intervals to replenish the fire. A complete L. R. Teeple Co. control of this kind, used on the Iron Fireman stoker and known as the Selective Synchrostat is shown by Fig. 1. The large time dial at the top rotates once every 24 hr. The "day" and "night" hands are adjustable and move with the plate. As they pass under the fixed pointer at the top, the dual control thermostats are automatically switched. At the lower right is the frequency of stoker operation dial by which refueling can be set for one, two, three or four hour intervals and, at the lower left, a dial which controls the length of the stoker refueling operation. This period is also adjustable. The frequency and length of refueling intervals depends upon the size of installation and type

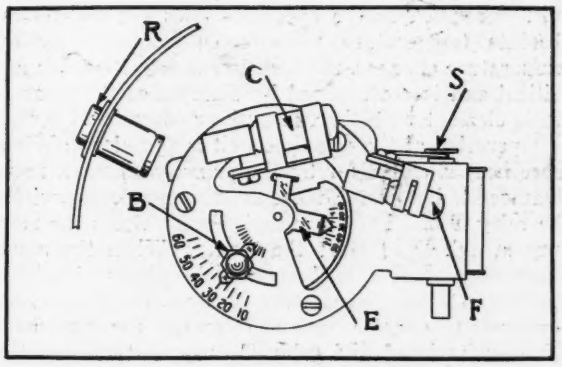


Fig. 4. Details of the Stokatherm timer mechanism

of coal used and the controls are set manually to meet local requirements. After this, operation is entirely automatic.

Figure 3 shows the Stokatherm Control System of The Mercoid Corp. which meets the demand for heat; refuels or fires the stoker at intervals, with corrections for variations in fuel and fire conditions, to maintain a minimum fire during periods that the thermostat is in the off position, so as to prevent overheating and to conserve fuel; stops the stoker if the fire should go out, to prevent filling the furnace with unburned coal; stops the stoker if the hopper is empty, to stop unnecessary operation. This is accomplished by adding to a motor driven timer a stack temperature element called the Pyratherm, actuated not by maximum or minimum temperature settings, but from a small differential of change in temperature. The Pyratherm controls the operation of the timing motor and refueling mechanism. It consists of a bimetal coil inserted in a convenient location in the uptake and carrying on the outer end a ratchet and Mercoid switch.

This ratchet is arranged so that on a change in temperature the circuit opens or closes. For instance, after the stoker has stopped, the stack temperature gradually drops and the Pyratherm element follows these changes. If the stoker is started again, the temperature increases and this temperature change, operating through the ratchet arrangement, tilts the Mercoid switch to open the Pyratherm circuit. As the stoker continues to operate the temperature gradually increases up to a maximum fixed by the stoker speed and boiler design. When the stoker stops, the temperature again drops and this change in temperature, again acting through the ratchet, closes the Pyratherm circuit. Inasmuch as the operation does not depend on absolute temperature measurements but simply on temperature changes, the instrument adjustment is not critical and is not affected by changes of the thermostatic element with time, growth or corrosion.

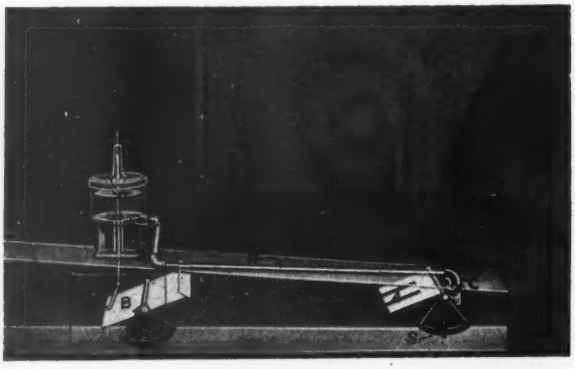


Fig. 5. The Volumeter used with the Iron Fireman stoker for automatic adjustment of air supply

Operation of the complete unit is as follows: When more heat is called for by the primary element, room thermostat, hot water thermostat or pressure switch, the relay T of Fig. 3 is energized and closes the mercury switch D to start the stoker. When the stack temperature starts to increase, the timer circuit is opened and the timer motor M stops but the stoker continues to operate until the demand for more heat has been satisfied and relay T drops out to stop the stoker.

When this occurs the stack temperature begins to drop and the Pyratherm circuit closes to start the timer motor M and energize solenoid S. The timer mechanism at the top of Fig. 3 is shown in detail by Fig. 4. At a definite interval after the timer motor starts, switch F, in parallel with the room thermostat, is closed by the timer and the stoker started for refueling. This time interval can be varied from 10 to 60 min. by means of the adjustment B. Inasmuch as the timer motor does not run continuously, but is started after the stoker stops, and the stack temperature decreases, the firing intervals can never be shorter than that indicated by the adjustment B.

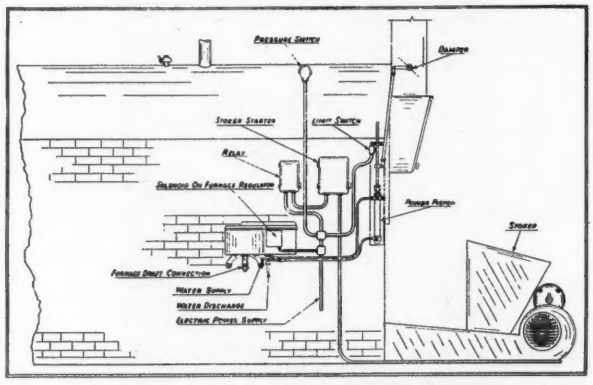


Fig. 6. Typical layout of the Carrick Sequence Control to prevent blow back in "on and off" stoker installations

The length of stoker operation during each refueling is not definite but depends on the condition of the fire as determined by the Pyratherm. Thus, if the fire is in good condition, the fire will come up soon after the stoker blower starts and the increase in stack temperature will open the Pyratherm circuit very quickly. This stops the stoker motor and the timer motor M and de-energizes solenoid S to release the gear train which immediately returns to its starting position ready to start a new cycle when the stack temperature drops to reclose the circuit. If the fire is not in good condition, the firing period will be longer but the operating cycle is the same. In this way, variations in the burning rates of different coals are taken care of automatically and the stoker operates only long enough to build the fire up.

Should the stoker start up at a refueling interval and the hopper be empty or the fire out, the Pyratherm circuit would not open and the stoker would continue to operate for a period fixed by adjustment C. At the end of this period outfire switch C would trip and the stoker would stop, thus preventing the stoker from filling the furnace with unburned coal. After the fire has been rekindled the stoker must be started by pressing hand reset button R.

With two or more boilers operating in parallel, a single control starting all stokers simultaneously may be used or each boiler may be equipped with a separate control. The first is simpler while the second is more flexible as the different units may be set to operate in sequence at intervals of a pound or two. The fuel economy is slightly better and electrical disturbances minimized by the sequence operation of motor starting.

None of the above controls consider draft requirements, either in the air supply duct or in the furnace.

The fan being driven directly from the stoker motor operates at a fixed speed and by means of speed or damper adjustments may be set from CO_2 readings at the best point for any particular coal. If the fuel bed could be maintained constant such regulation would be sufficient. Unfortunately, this cannot be done, but, by taking advantage of pressure changes in the air duct these furnace changes may be compensated for. Thus a thin fire having little resistance causes a drop in air duct pressure below normal while a thick fire causes an increase in pressure. These pressure variations may be used, either through hydraulic or electric drive, to operate a damper in the duct.

A self contained automatic regulator, the Volumeter, used by the Iron Fireman stoker, is shown by Fig. 5. The damper A is adjusted for the particular coal used and acts as a fixed damper, gravity counterweighted so that, although it tends to seek the position determined by setscrew adjustment S, it is not rigidly fixed and is free to move with sudden changes in air flow such as occur when the fan starts or stops. The position of the second damper B is determined by the position of the floating piston P, the under side of which is connected by means of pipe R to the duct pressure at C ahead of damper A. The top side of P is vented to atmosphere. For normal operation damper B and piston P are adjusted at about mid-position. If the fire gets thin the duct pressure drops slightly and the damper B closes proportionately. This reduces the flow of air, slows up combustion and builds up the fire. If the fire is too thick the reverse action takes place and the fire is burned down to normal.

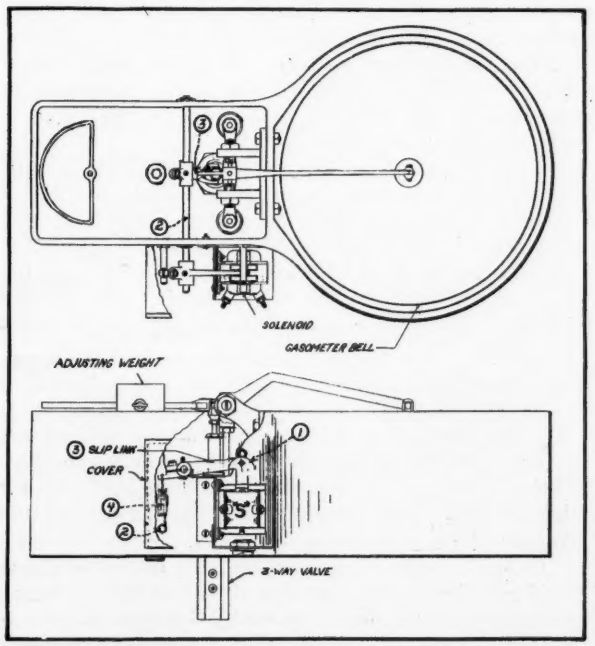


Fig. 7. Arrangement of the sequence solenoid on the Carrick furnace pressure regulator

Furnace draft can be regulated by the conventional furnace pressure regulator as described in the previous issues. With low stacks or buildings, a simple regulator works sufficiently well but for high buildings where natural draft may be run up to several inches simple control of this kind may involve difficulties. When the stoker stops the damper regulator closes the damper tight and the gasometer bell rests on the bottom stop. When the stoker and fan start, the furnace pressure is increased suddenly and, although the pressure device responds quickly, the damper itself cannot be opened quickly enough to prevent a positive pressure in the furnace and blow-back occurs. This blow-back may be prevented by interlocking the damper regulator with the stoker motor. A control of this kind, the Sequence Control of the Carrick Engineering Co., is shown by Fig. 6 installed for pressure switch operation.

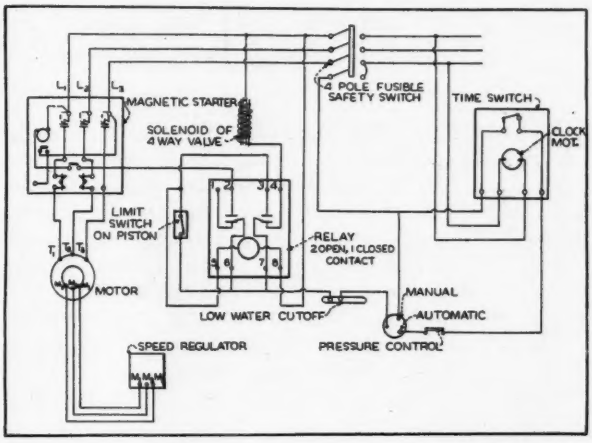


Fig. 8. Wiring diagram showing the solenoid and limit switch interlocks on the Carrick Sequence Control

The furnace pressure regulator is of the gasometer type which operates the damper through a hydraulic cylinder. (See Fig. 4 page 576, October, 1935, issue for details of this regulator.) The gasometer is equipped with a solenoid S as shown by Fig. 7 and the hydraulic cylinder with a limit switch as shown by Figs. 6 and 8. These are interlocked with the stoker starter. When the stoker is off, the gasometer bell is down and the damper closed. When the pressure switch (or thermostat as the case may be) calls for more heat, the solenoid S is energized and pulls the plunger 1 downward to rotate shaft 2 and depress slip link 3. This lifts the gasometer bell and lowers the four way valve to open the damper in exactly the same way as if gasometer bell were operated by a high furnace draft. As the damper nears its open position the limit switch is tripped, starting the stoker and de-energizing the solenoid, thus allowing the stoker starter to operate. When the solenoid is de-energized spring 4 returns the solenoid plunger and slip link to normal position and the damper regulator takes control and brings the furnace pressure to the desired operating condition. In this way the damper is open when the stoker starts and blow-back is positively prevented without interfering with the operation of the furnace pressure regulator. The same control is, of course, applicable to gas or oil firing. A wiring diagram is shown by Fig. 8.

This same control is also built for all electric operation, the gasometer and hydraulic cylinder being replaced by a Hays diaphragm type draft gage with electric contacts and remote control for the damper motor. The interlock arrangement is the same as before but

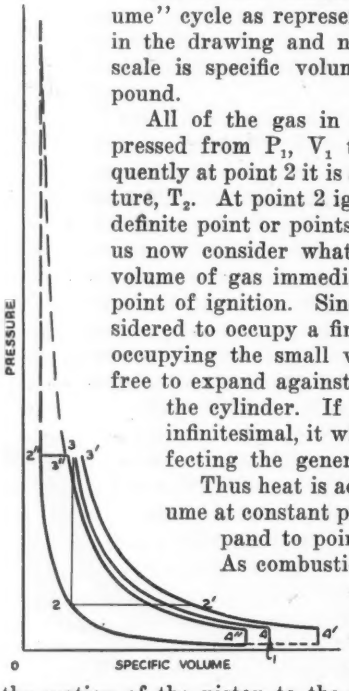
(Continued on p. 680)

Combustion in the OTTO CYCLE ENGINE

"Combustion at constant volume" rolls off the tongue easily but the process itself is infinitely more complicated as is shown in the following analysis*

THERMODYNAMIC ANALYSES of the Otto cycle normally dismiss the combustion process with the sentence, "heat is added at constant volume." As early as 1906 the thermodynamic nature of the process of combustion was indicated by experiments in a closed vessel. There has been rather a widespread feeling, however, that the combustion process in an engine might be essentially different from that in a bomb because of the part played by turbulence in spreading the flame but recent experiments indicate the essential similarity of the combustion process in engines and enclosed vessels.

Turbulence is, of course, extremely effective in equalizing any existing temperature differences that may momentarily exist in the cylinder but, since the rate of flame propagation depends on the transfer of heat from the burned to the unburned gas, turbulence is equally effective in increasing the flame velocity.



Let us now consider the "constant-volume" cycle as represented by 1, 2, 3 and 4 in the drawing and note that the abscissa scale is specific volume or cubic feet per pound.

All of the gas in the cylinder is compressed from P_1, V_1 to P_2, V_2 and consequently at point 2 it is at a uniform temperature, T_2. At point 2 ignition occurs at some definite point or points in the cylinder. Let us now consider what happens to a small volume of gas immediately adjacent to the point of ignition. Since combustion is considered to occupy a finite time, the medium occupying the small volume in question is free to expand against the unburned gas in the cylinder. If the volume chosen is infinitesimal, it will expand without affecting the general cylinder pressure.

Thus heat is added to this small volume at constant pressure and it will expand to point 2^1 on the diagram. As combustion point 3^1 (adiabatically since we are assuming no heat interchange). It will then be re-expanded by the motion of the piston to the exhaust pressure. If we consider now the last part of the charge to burn, we see that it is compressed before combustion to the maximum cycle pressure at point 2″. The heat of combustion then expands it, at constant pressure since it is small compared to the total volume of gas, to point 3″ whence it is expanded by the motion of the piston.

Similarly, any intermediate small volume of gas will go through a cycle in which heat is added at some intermediate pressure level. Thus we see that the "constant-volume cycle" is really the resultant of the sum of an infinite number of different cycles in each of which heat is added at constant pressure. We also observe that there is a difference in specific volume and, therefore, in temperature from the last part of the charge to burn to the part near the ignition point.

In order to indicate the possible magnitude of this temperature difference, it has been calculated for an assumed case where the compression ratio is 5, the inlet conditions are $p_1 = 14.7$ lb. per sq. in., $T_1 = 600$ deg. F. absolute, $C_v = 0.169$ and $C_p = 0.238$ B.t.u. per lb. Heat added, 650 B.t.u. per pound of air. The tabulation below gives the results of the calculation.

Point	P	V	T
2	140	3.02	1140
3	611	3.02	4990
2′	140	10.2	3870
2″	611	1.05	1740
3′	611	2.57	5900
3″	611	2.71	4470

$T_{3'}$ represents the temperature near the spark plug after combustion is complete. $T_{3'}$ is some 1500 deg. F. higher than $T_{3''}$, the temperature of the last part of the charge to burn at the same instant.

It is now fairly well accepted that detonation is a rapid reaction in the last part of the charge to burn, probably initiated by compression ignition ahead of the flame front. If the reaction is sufficiently rapid, combustion can no longer be at constant pressure but will approach the conditions of constant volume. In the limiting case of instantaneous combustion of the last part of the charge to burn, the combustion from point 2″ at constant volume would cause a local pressure of 1960 lb. per sq. in. with a corresponding temperature of 5590 deg. F. absolute.

Owing to the increase in specific heat and the change in chemical equilibrium at high temperatures as well as to the fact that combustion is never instantaneous, this pressure and temperature will never be reached but they are the limiting values that may not be exceeded under the conditions of our assumption. Although we are dealing with approximations, the temperature of the gas participating in detonation is probably lower, and certainly not very much higher, than the temperature elsewhere in the cylinder.

Thus, it cannot be the high temperature alone that causes the destructive effects of detonation but perhaps a combination of extremely high pressures and increased local heat conduction due to the high density of the detonating part of the charge.

* From N.A.C.A. Technical Note No. 533 by E. S. Taylor of the Daniel Guggenheim Aeronautical Lab., Massachusetts Institute of Technology.

Installation *of* Internal Combustion Engines

Safety and reliability demand care in installation and use and the following remarks taken from the recommendations of the National Board of Fire Underwriters give some of the requisites of good practice

IN GENERAL internal combustion engines used in industries are of two types; the carburetion engine burning gas, gasoline, kerosene or other fuels which pass through a carburetor or mixing valve before admission to the cylinders or combustion chamber; the compression ignition engine burning kerosene or heavier fuels which are introduced directly into the cylinder without being vaporized or mixed with air in combustible proportions.

Engines should be installed only in well lighted and ventilated buildings in a location which will permit ready accessibility for repairs, cleaning and replacement. They should be installed on solid foundations in such a way that sagging of piping and leakage of joints will not be brought about through vibration. If possible engines should be located on the ground floor. Where flammable dust prevails the engine should be enclosed in a suitable compartment, preferably of fire-resistive construction, well ventilated.

Suitable instructions for operation and maintenance should be supplied with all engines and where feasible placed on the engine or mounted on the wall nearby. The apparatus should be kept clean and free from hazardous accumulations of dirt, rubbish, oil and fuel. Due consideration should be given to the cleaning of cylinders, valves, exhaust pipe, etc., as often as the quality of fuel may necessitate. Stuffing boxes of pumps or valves should be kept tight and when leakage cannot be stopped by drawing up the nut, the old packing should be removed and replaced by new packing of suitable quality.

Regardless of the type of engine, fuel must be provided and the necessary tanks are known as main supply tanks, auxiliary tanks, gravity feed tanks, day supply tanks, etc. These latter provide a convenient and continuous supply of fuel to the engine. Being installed inside, the oil is kept warmer and can be measured and proportioned to the engine more easily than when drawn from a large outside, usually underground, tank.

The safest kind of oil supply to the engine is that in which all piping and the tops of tanks are located below the level of the engine base and which require the use of a pump. In this case the breakage of a pipe will not result in a continuous discharge of oil in the building. Gravity feed should be permitted only under exceptional conditions and in small supplies. For instance, for compression ignition engines operated on fuels having a flash point not lower than 100 deg. F.

Liquid capacity of a day supply tank should not exceed 275 gal. and the aggregate capacity of such tanks installed within the building should not exceed twice this volume. When the oil has a flash point about 150 deg. F., the restrictions of the day tank capacity may be exceeded if the character of the tank support, building construction, possibility of injury to tank or connections in case of fire or emergency are carefully considered. Where more than one day tank serves the fuel line, the tanks should be connected with the gravity feed line to the engine pumps through a manually operated three-way valve in such a manner that not more than 275 gal. can be discharged by gravity at any one time.

Day tanks should be constructed of steel with welded, brazed or riveted and soldered joints, the thickness of the material depending upon the capacity of the tank, for instance 16 ga. sheet with a nominal thickness of 0.0625 in. for tanks of up to 180 gal. capacity, and 14 ga. with a nominal thickness of 0.078 in. for larger tanks of from 180 to 275 gal. Tanks should be filled by a pump connected by full-weight iron or steel piping to the main storage tank and should be equipped with an overflow pipe, of at least two pipe sizes larger than the filling pipe, draining back to the storage tank. Gage glasses, the breakage of which will permit the escape of oil, should not be used.

Tanks or receivers of the pressure type should not have a capacity of more than 10 gal. and should be provided with a reliable gage and relief valve set to operate at a safe pressure and connected to an overflow to the main tank.

Receivers, when installed with engine supply pipe connections below the oil level, should be arranged so that the oil will automatically drain back to the main storage tank when the engine stops, leaving not over one gallon necessary for priming. If the engine supply pipe is connected to the tank above the oil level, automatic release of the pressure without draining the oil may be permitted.

Where fuel is raised by engine suction from an integrally assembled tank, the possibility of leakage should be reduced to a minimum and the pumps should have check valves located as closely to them as practical.

Except in the case of gravity feed lines, all piping to the engines should be installed with sufficient pitch so that fuel will drain back to the tank after the engine has been stopped. Unions, if used, should be all brass of standard metal-to-metal type with conical or spherical joints to obviate the use of packing or gaskets. A strainer should be provided in the oil supply line through which the fuel passes before reaching the

valves or parts that are likely to become clogged. Strainers should, of course, be readily accessible for cleaning and when intended for use where subjected to pressure, should be of a type which does not require the use of packing or gaskets. A shut-off valve should be provided between the fuel supply tank and the strainers.

Valves should be secured against leaks and shut-off valves in the liquid fuel lines should preferably be installed close to the supply. Piping should not be located in the same trench with other piping except when the other piping is used as a heating arrangement to provide for the proper flow of heavy fuels. When above ground, the piping must be protected, and, when under-ground, it should be laid below the frost line or protected by internal means against freezing.

Ignition and starting should be carefully considered and except as provided below only electrical or compression ignition should be employed. No method of ignition that introduces open flames or exposed highly-heated parts while the engine is in operation is considered acceptable practice.

Ignition by preheaters should be used only for starting and should be arranged so as to shut off as soon as the engine is firing regularly. Preheater torches burning gaseous or liquid fuels shall be designed to direct the flame properly and enclose it in a permanently mounted shield. Preheaters of the pressure type should be arranged so that the pressure should be released at or about the time they cease operation. Such torches should be marked with the type of fuel for which they are intended.

If gasoline is used for starting kerosene or fuel oil engines, it should be introduced directly into the cylinders and supplied to the engine by one of the following methods: 1. From an outside underground storage tank with the gasoline drawn by a hand pump permanently attached to the engine, into a feed cup of approved construction. 2. From a reservoir of the lift-out type attached to the engine, the capacity being limited to an amount not exceeding that necessary to produce a proper temperature for operating the engine with heavier fuel, in no case to exceed 1 gal. It should be arranged so that retention of gasoline after starting is automatically prevented. The body should be of sturdy construction with a reliable valve which will prevent the escape of gasoline when the reservoir is lifted out.

When engines have built-in supply tanks these tanks should be filled during daylight only and when the engine is not running. Filling of indoor gasoline tanks should be from approved safety oil cans and the source of the supply should be kept in a safe receptacle outside of the building.

Exhaust pipe should be of wrought iron, cast iron or steel, of sufficient strength to withstand the service and so connected with the engine, exhaust pot, or muffler that emission of sparks, flame or gas within the building is prevented. This requires adequate support throughout the entire length. Exhaust pipes should terminate outside the building at a point where the hot gases or sparks will be discharged harmlessly and not directed against combustible material, buildings, under loading platforms, etc.

Where the construction or arrangement of the building is such as to make it impractical to extend the exhaust pipe through a side wall, it may be extended through the roof of the power house, provided proper precautions are taken to prevent the discharge of sparks or hot particles on to the roof or on to other buildings. Such precautions may consist of a water spray in the exhaust pipe, a hood, spark arrester, or similar device. No exhaust pipe should be within 9 in. of any wooden lath and plaster partition, ceiling, or other combustible material except under special conditions.

For instance, where exhaust pipes larger than 2-in. iron pipe size pass through combustible partitions or roofs, they should be guarded by double metal ventilated thimbles 12 in. larger in diameter than the pipe, or by steel tubes built in brick work or fire-resisting material extending not less than 8 in. beyond all sides of the tube. Where such exhaust pipes are 2 in. standard iron pipe size or smaller, the distance between the outside of the pipe and the nearest combustible material should not be less than 2 in. Where pipes pass through finished walls enclosing air spaces, protection must be provided against flammable material dropping on the hot pipes.

Except as provided below, for compression ignition engines, exhaust pipes should not be connected into existing chimneys or flues unless the pipe extends to the top of the flue and the latter does not contain highly corrosive gases, such as products of combustion from gas, coal, or oil burning appliances. Compression ignition engines may exhaust to an inside flue or chimney equivalent to 8 in. of brickwork with a standard flue lining, or 6 in. of reinforced concrete with no woodwork within 4 in., or may connect to any interior or exterior flue, chimney or stack not used for a medium or high heat appliance, provided the flue, or stack is in good condition and impervious to the exhaust gases.

Water pockets in exhaust pipes shall be provided with suitable drains and where the exhaust pipe is fixed immovably in a wall, a union or suitable flange should be provided to facilitate cleaning and repairs. The exhaust pipe is likely to become hot and should have additional protection where flammable dust is present.

Crank cases and similar chambers or receptacles, containing lubricating oil subject to heating, should be vented to avoid the formation of hazardous mixtures with air and to remove vapors. Cranks and other rapidly revolving or reciprocating parts should be properly shielded to prevent injury to the operator as well as to prevent the throwing of oil in and around the installation. Engines should be provided with channels, drips or pans where necessary, to collect such waste lubricating oil as might otherwise drain to the floor.

Gage glasses or sight feeds for lubricating oil, the breakage of which would permit the escape of oil into the room, should be protected against mechanical injury. Piping handling lubricating oil under pressure should be made up of tight joints not dependent upon gaskets. Where gaskets are employed with flanged fittings, they should be of material not readily affected by either the lubricating oil or the temperatures involved. The engine base should be closed and should not be used as a storage space for oily waste or other materials.

It's the Humidity

Just what is humidity? Some people explain it as the amount of moisture absorbed by the air, and speak of "dry" and "wet" air. The air, however, has nothing to do with humidity and furthermore, there is no such thing as dry or wet air as this article shows.

By Geo. P. Pearce

HUMIDITY is the amount of moisture in any space and it depends upon just two things; the temperature and the amount of moisture available. Without, at present, considering the values and meanings of absolute humidity, relative humidity, psychrometric charts and so forth, let us look into the matter in a simple way and find out what it is all about.

First, let us obtain a large glass bottle which has a capacity of 1 cu. ft. and attach a valve, a thermometer, and some kind of a pressure gage to the cork. It is not important but it will be handy if the gage shows the absolute pressure in the bottle in inches of mercury. We will now connect a good vacuum pump to the valve and pump the air out of the bottle to the point where the gage registers zero, in other words, until the bottle is quite empty. We then weigh it and obtain the tare weight. Next we proceed very carefully to admit water, drop by drop, which quickly evaporates into low pressure steam and we continue to do this until the water will no longer evaporate because the bottle has become as full as it can with saturated steam or, more correctly, vapor. Now we weigh the bottle again, subtract the tare weight and discover how much water has been evaporated to fill the cubic foot of space. If the thermometer reads 74½ deg. F. we shall find that there are 9 grains of water vapor in the cubic foot and that the absolute pressure in the bottle has risen to 0.86 in. of mercury. Thus we have discovered that a cubic foot of steam at 74½ deg. F. weighs 9 grains and has a vapor pressure of 0.86 in. of mercury.

If we are performing this experiment at sea level we will, under standard conditions, be surrounded by air at a pressure of 29.921 in. of mercury, that is, the barometer will show that height, and by simply subtracting the pressure in the bottle from the pressure of the air we can determine that the air is trying to force its way into the bottle by an excess pressure of 29.061 in. of mercury. Let us now open the valve and permit all the air to enter that will. Again we weigh the bottle, subtract the tare weight and the 9 grains of water vapor and find that a total of 505.2 grains of air has entered. We will now tabulate the results as follows:

Temperature 74½ deg. F.

	Grains	Pressure, in. mercury
Weight of saturated steam	9.0	0.86
Weight of air	505.2	29.061
Weight of mixture	514.2	29.921

We will be correct if we state that the bottle contains one cubic foot of air at 74½ deg. F. and 100 per cent humidity, for we know that no more moisture will evaporate in the bottle. If we wish we could take a cubic foot of still air close to the surface of the sea on a day when the temperature registered 74½ deg. F. and we would find exactly the same weight of water vapor and air, and the same partial pressures.

Let us repeat the experiment on a hot day when the temperature is, say 106 deg. F. This time we shall discover quite a change in conditions for it will take 24 grains of moisture to fill the bottle with vapor, or saturated steam, and the pressure will rise to 2.34 in. of mercury. The air will weigh 452.7 grains and the pressure difference will be 27.581 and our second tabulation will be as follows:

Temperature 106 deg. F.

	Grains	Pressure, in. mercury
Weight of saturated steam	24.0	2.34
Weight of air	452.7	27.581
Weight of mixture	476.7	29.921

Again we would find that these figures represent the contents of every cubic foot of quiet air above the sea or any other place where there is ample water and standard pressure on a day when the temperature is 106 deg. F. Again we can correctly say that the bottle contains air at a temperature of 106 deg. F. and 100 per cent humidity.

The next time we try the experiment let us pick a cold wintry day when the temperature is 23½ deg. F. We shall be unable to find any water to drop into the bottle to evaporate because it will all be frozen solid. That need not bother us, however, because we can drop a little ice powder in which will sublime away until the bottle becomes full of vapor and upon checking this we shall find that just 1.5 grains of ice have disappeared and that the vapor pressure is 0.125 in. of mercury. Upon opening the valve 572.6 grains of air will enter before the total pressure in the bottle balances the air pressure of 29.921 in. of mercury. Our third tabulation is as follows:

Temperature 23½ deg. F.

	Grains	Pressure, in. mercury
Weight of saturated steam	1.5	0.125
Weight of air	572.6	29.796
Weight of mixture	574.1	29.921

A similar experiment made when the temperature is 61½ deg. F. will result in a fourth tabulation as follows:

Temperature 61½ deg. F.

	Grains	Pressure, in. mercury
Weight of saturated steam	6.0	0.55
Weight of air	523.3	29.371
Weight of mixture	529.3	29.921

We will make one more test on a day when it is 83 deg. F. in the shade which will provide our fifth tabulation as follows:

Temperature 83 deg. F.

	Grains	Pressure, in. mercury
Weight of saturated steam	12.0	1.14
Weight of air	492.5	28.781
Weight of mixture	504.5	29.921

Thus we have discovered the maximum amount of water vapor that a cubic foot of space will hold at the temperatures tested and we have also discovered that this depends entirely on the temperature and the presence of sufficient water to make a saturated vapor. Also note that the amount of moisture present has been expressed by its weight in grains per cubic foot. This is the usual way that absolute humidity is expressed, i.e.: grains of moisture per cubic foot. We have furthermore discovered that the presence or absence of air does not change our figures and, in fact, has nothing to do with the humidity.

So far we have considered only a saturated condition. Suppose we now take our bottle full of water vapor at 106 deg. F., which we found contained exactly 24 grains of moisture, and partition off a quarter of the volume and then pump all the vapor out of this quarter. Then we remove the partition and proceed to find out what has happened. Since we have taken a quarter of the vapor away that will reduce the weight by six grains so all that is left is 18 grains of moisture. The three quarters of the volume we left in the bottle has, since we removed the partition, expanded to four quarters, therefore the vapor pressure will have dropped in the ratio of 4 to 3 and, since the temperature has not changed, the gage will drop to $2.34 \times 0.75 = 1.755$ in. of mercury. The excess pressure of the air will become $29.921 - 1.755 = 28.166$ in. of mercury and a cubic foot of air at 106 deg. F. and at this pressure will weigh 462.4 grains so our sixth tabulation is as follows:

Temperature 106 deg. F. Humidity 75 per cent.

	Grains	Pressure, in. mercury
Weight of vapor	18.0	1.755
Weight of air	462.4	28.166
Weight of mixture	480.4	29.921

We thus find that a cubic foot of air at 106 deg. F. and 75 per cent humidity contains 18 grains of moisture, or that the absolute humidity is 18 grains of moisture per cubic foot. Also note that this cubic foot will take up 6 grains of moisture before becoming saturated.

Let us perform one more experiment on the cubic foot of saturated vapor at 106 deg. F. This time we will remove $\frac{15}{16}$ of the 24 grains of moisture which will leave $\frac{1}{16}$, or 1.5 grains. This $\frac{1}{16}$ remaining will have to expand to 16 times its volume in order to fill the cubic foot which, since the temperature is kept constant, will result in the pressure dropping to $\frac{1}{16}$ of its original value, or to $2.34 \times 0.0625 = 0.146$ in. of mercury. With this pressure in the bottle the differential pressure of the air will become $29.921 - 0.146 = 29.775$ and the weight of the air which enters the bottle when we open the valve is 488.8 grains and the tabulation is:

Temperature 106 deg. F. Humidity 6.25 per cent.

	Grains	Pressure, in. mercury
Weight of vapor	1.5	0.146
Weight of air	488.8	29.775
Weight of mixture	490.3	29.921

Thus we discover that air at 106 deg. F. and 6.25 per cent humidity contains 1.5 grains of moisture per cubic foot and that it will take up 22.5 grains more before becoming saturated or 100 per cent relative humidity. By referring to our third experiment we find that at 23½ deg. F. it took just 1.5 grains of moisture to saturate a cubic foot so it is obvious that if we reduce the temperature of our cubic foot at 106 deg. F. and 1.5 grains of moisture down to 23½ deg. F. we shall have 100 per cent humidity. Note that this is the point at which the slightest decrease in temperature will result in moisture being deposited on the nearest surface and therefore is called the "dew point."

A question arises about the vapor tension because we find that while it was 0.125 in. of mercury in the third experiment it is now 0.146 for the same weight and volume of moisture. The explanation is simple; the 1.5 grains of vapor per cubic foot at 106 deg. F. is simply saturated steam at 23½ deg. F. which has been superheated 82½ deg. F., thus making the total temperature 106 deg. F. and due to this superheat the pressure has risen from 0.125 in. of mercury up to 0.146 and we can prove this by multiplying this pressure by the ratio of the two temperatures expressed in absolute degrees thus: $0.146 \times (483.1 \div 565.6) = 0.125$ in. of mercury which shows that the pressure would become the correct vapor pressure when saturation temperature was reached. Be careful to note that these figures apply only when the space under consideration is kept at precisely 1.5 grains per cubic foot during the entire temperature drop. This experiment teaches us that every time the humidity is less than 100 per cent the moisture in the air is in a superheated condition.

Now it becomes clear why a wet bulb thermometer generally gives a lower temperature than a dry bulb thermometer close to it when both are in a strong current of air. Take the above example where the dry bulb reads 106 deg. F. and the humidity is only 6.25 per cent. We have just found that under the conditions in the bottle there was a vapor pressure of 0.146 in. of mercury and we have also found that the vapor pressure for water at 106 deg. F. is 2.34 in. of mercury. Now it is obvious that the moisture around the wet bulb thermometer will be evaporating with a pressure of 2.34 in. of mercury and it will meet only the resistance of 0.146 in. of mercury, therefore it will continue evaporating. Evaporation is a strong cooling process so the water will be cooled down until it reaches a point where the vapor pressure due to its temperature balances at 0.146 in. of mercury, which will be at 27½ deg. F. Therefore, if the wet bulb thermometer were 100 per cent efficient it would read that temperature but, of course, it is not, so it will read a higher temperature which will depend upon the design of the instrument, the velocity of the air stream and other factors. There is, however, no need to worry about these because they have all been taken into consideration when making up the chart, or table, which accompanies the wet and dry bulb thermometer outfit, or hygrometer, so if you use the instrument according to the directions supplied with it you will get satisfactory results.

Electron Tubes Replace Engine Generator Unit

HERE is an article that should make power plant engineers sit up and take notice. Suppose you were operating an engine driven generator and the management called you in and said, "Next month, we're going to replace the generating unit you're operating with a bank of vacuum tubes. Can you take care of it?" This is exactly what happened in the plant referred to in this article. If this happened in your plant, would you be sufficiently familiar with electron devices to say. "Yes"?

POWER PLANT designers and operators in general have not given a great deal of attention or thought to the application of electronic devices in their work. From time to time perhaps they have come across instances where photoelectric cells are used as smoke recorders or where amplifiers are used in control equipment, but such applications have been regarded only with casual or passing interest. That electron devices warrant more than passing interest from the power plant engineer is indicated by a recent change made in the electric power system of the New York Shipbuilding Corp. at their Camden, N. J., plant. This change involved the replacement of a 25-cycle, engine-driven generating unit by a bank of thermionic tubes. The installation is completely described in a paper by A. Schmidt, Jr., and R. C. Griffith, both of the General Electric Co. at Schenectady, published in the October number of Electrical Engineering and to be presented for discussion at the winter convention of the American Institute of Electrical Engineers in New York, January 28 to 31, 1936. The description of the installation as presented here was abstracted from this paper.

The plant involved generates its own power for a load consisting principally of 60 cycle and direct current motors, as well as several hundred horsepower of 25 cycle alternating current motors. This 25 cycle current up to the time the change was made was furnished by a separate engine driven alternator operating at that frequency. In analyzing the power situation, it was anticipated that during the next few years these 25 cycle motors would be replaced gradually by 60 cycle motors and there would be a steadily decreasing need for the 25 cycle generating equipment.

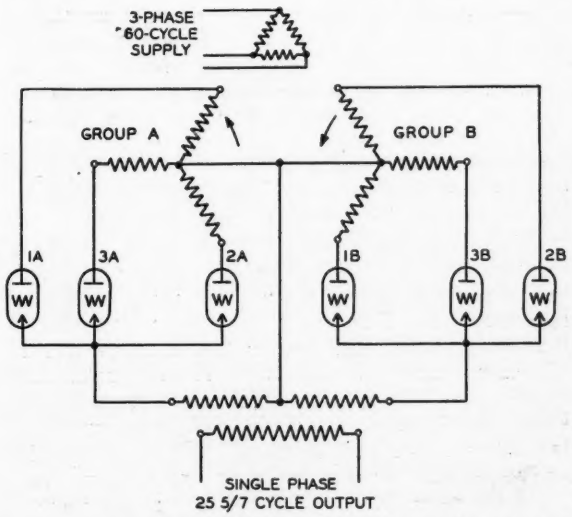


Fig. 1. Simplified diagram showing the principle of the 3 phase 60 cycle to single phase 25 5/7 cycle frequency changer

In considering the possibilities of a new source of 25 cycle power it was necessary also to take into account the fact that during certain periods of the week the demand for direct current power is considerably less than the capacity of the smallest d.c. generating unit in the plant so that an efficient source of a few hundred kilowatts of direct current power would return an appreciable saving. This situation led to the installation of a static frequency changer using 12 grid-controlled mercury vapor tubes and delivering 300 kv-a. at 220 v., 2 phase 25 5/7 cycles from a 2300 v., 3 phase 60 cycle source. When the 25 cycle power is no longer required, the 60 cycle transformer winding will be reconnected for a lower secondary voltage. A portion of the control equipment will be disconnected and the apparatus will be available as a rectifier with an output of 300 kw. at 350 v.

The operation of this frequency changer is rather complicated to those not familiar with the characteristics and functions of modern electron tubes and no attempt will be made here to present a detailed description of its operating principles. Such a converter makes use of gas filled grid controlled tubes, arranged as shown in Fig. 1. The characteristics of such tubes is that with a certain voltage across the tubes they will pass no current until the grid is given a certain

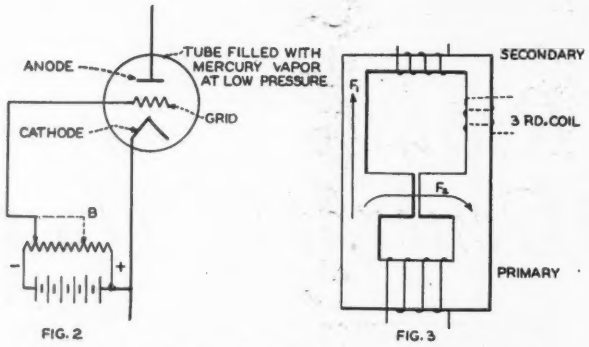


Fig. 2. Principal elements of the grid controlled gaseous tube
Fig. 3. Type of impulse transformer used in the system

value of electric charge. Suppose, for example, we have such a tube, illustrated in Fig. 2. If a negative charge of say 20 v. is placed on the grid by connecting a battery and a potentiometer in the circuit as shown, no current will pass between the cathode and anode even though a potential of several hundred volts may be applied across them. Assume now that we move the potentiometer slider to the point B so as to decrease the negative potential on the grid to a value of say 10 volts (negative). At this point the tube will "fire" as it is called, and the cathode-anode current will suddenly rise to a maximum. In other words, the tube suddenly becomes a good conductor.

After this condition is reached the grid will no longer have any control over the tube current even though it is given a high negative value. If, however, the plate current should be interrupted for even a very brief instant, and assuming the grid is still sufficiently negative, the latter will instantly regain control and all current will cease.

Thus it is evident that if such a tube is connected in an alternating current circuit, the grid has the opportunity of regaining control every half cycle when the voltage passes through zero.

The control voltage applied to the grid may be obtained in a number of ways, depending upon the application of these tubes, but in the system under consideration it is obtained from a small synchronous motor generator set having a frequency ratio of 7 to 3. Since this set operates from the 60 cycle system, this provides the proper frequency control voltage to produce the desired 25 cycle output. Actually the output is 25 5/7 cycles, i.e.

$$\frac{3}{7} \times 60 = 25\ 5/7$$

The grid control circuit in this system involves the use of impulse transformers as shown in Fig. 3. The impulse transformer is a transformer which, when excited by a sinusoidal primary voltage, has a sharply peaked nonsinusoidal secondary voltage. Figure 3 is a sketch of a simple impulse transformer with one

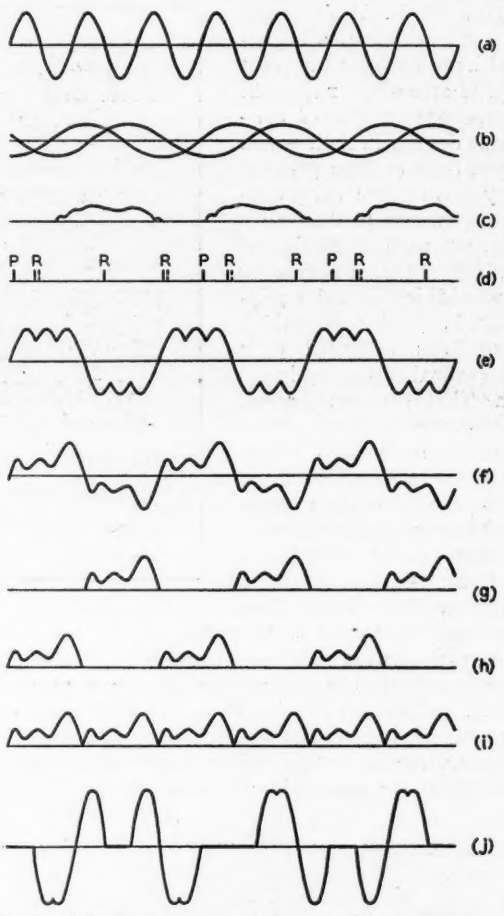


Fig. 5. Voltages and currents when supplying power to an induction motor

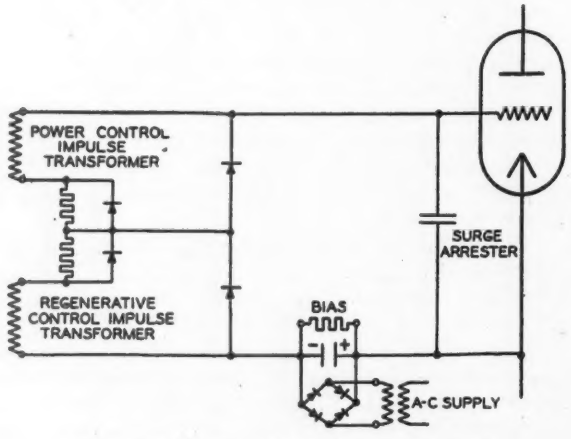
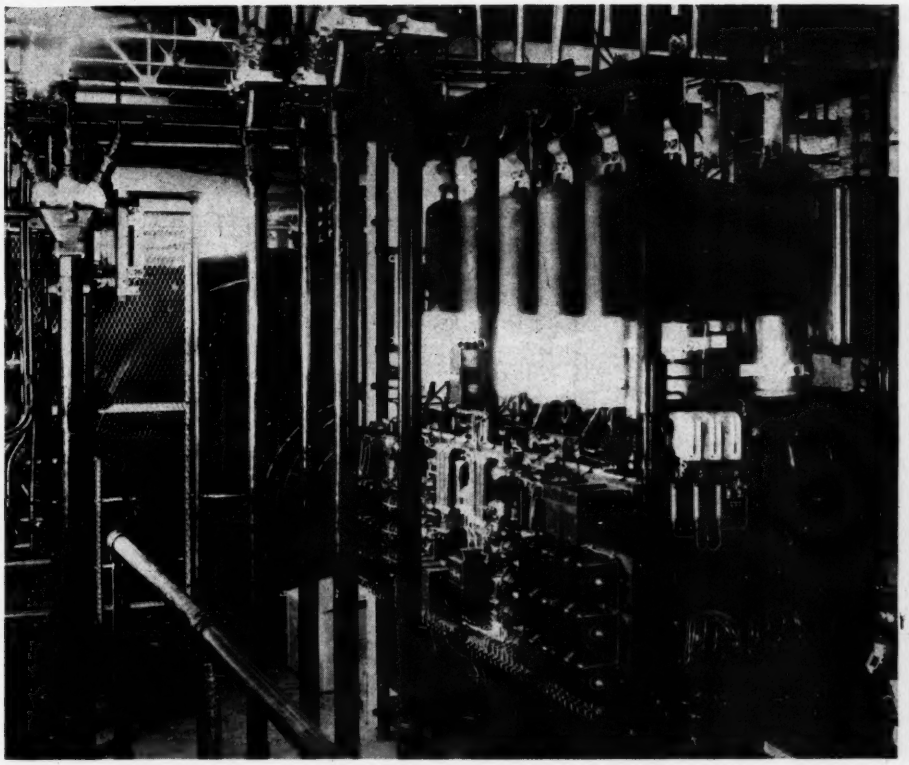


Fig. 4. Grid circuit used in the frequency changer

secondary winding. The primary flux passes through two parallel paths, F_1 and F_2, when the density is low and as the reluctance of F_1 is less than the reluctance of F_2, a relatively large secondary voltage is induced. After F_1 has saturated, however, most of the flux passes through F_2 and the rate of change of flux through F_1 is small. If a constant direct current is passed through another coil wound on F_1, the time at which the peak of voltage occurs will be different because the core density will be zero at a different time. By varying the magnitude and direction of this direct current, the time at which the peak occurs can be changed plus or minus 90 deg.

If the number of ampere turns in the third coil is slightly greater than the number of primary ampere turns, no secondary voltage will be induced because



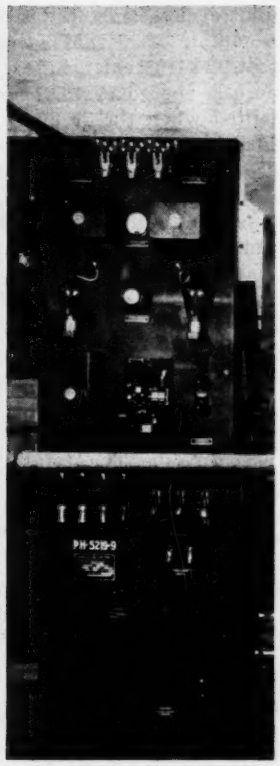


Fig. 6. (Left) Assembly of tubes and control tranformers. Fig. 8. (Right) Control Panel. (Photos courtesy General Electric Co.)

the core will be saturated continually. Now assume that the current in this third coil varies in some regular manner. The flux through F_1 will be the sum of the fluxes induced by the primary and the third coil, and a peak of secondary voltage will occur when the resultant flux does not saturate F_1.

As it is necessary to supply excitation to each tube at two different times, two impulse transformers are necessary for each tube. The one supplying excitation for power control has a primary coil, a secondary coil, a frequency control coil, and a hold-off coil, the latter two surrounding F_1. The frequency control coil receives pulses of direct current at the required output frequency; the hold-off coil is in series with the output transformer primary winding associated with the group of tubes opposite to the group in which the tube under consideration is placed. The impulse transformer supplying excitation for regeneration has a primary coil, a secondary coil, and a phase advancing coil, the latter surrounding F_1. The phase advancing coil is in series with the half of the output transformer primary associated with the tube under consideration.

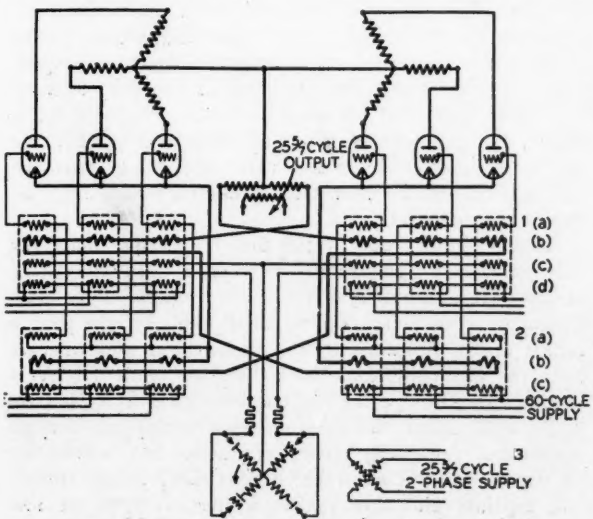


Fig. 7. Schematic diagram of power and control circuits

A small synchronous motor generator set having a frequency ratio of 7 to 3 furnishes power to the frequency control circuit which, in turn, supplies alternate pulses of direct current to the frequency control coils of groups A and B. By proper timing, just three consecutive tubes are fired in each group. With a unity power factor load the flux induced by the current in the hold-off coils adds to that induced by the current in the frequency control coils without further effect, but when the load is reactive the hold-off current maintains F_1 in a saturated state until the load current approaches zero.

The phase of the regenerative excitation must be advanced as the load increases. This is accomplished by the phase advancing coils.

Figure 4 shows the complete grid circuit for one tube. With this copper oxide rectifier combination, the impedance presented is low when the grid is excited, and the resistor limits the positive ion current to a value which does not reduce the bias voltage appreciably.

Figure 5 shows the input current with an induction motor load. In the operation of this converter the given anode fires during a specified portion of the output cycle only once in three output cycles or seven

input cycles, hence the input current may be expected to contain fractional harmonics, namely 1/7 and odd multiples thereof. Since these fractional harmonics increase the generator losses, their magnitude must be limited when the frequency changer output is a considerable portion of the generator rating. Reduction of harmonic input currents may be effected by the use of sufficient anodes and different anode potentials to secure an output voltage wave with small harmonic content.

Efficiency

A frequency changer of this type has the following circuit losses: (1) input transformer loss; (2) output transformer loss; (3) arc loss in tubes; (4) cathode heater and control circuit losses. The utility factors of the input and output transformer are 0.62 and 0.83 respectively. The total transformer loss is 8.6 per cent at full load and 0.07 power factor. The arc loss is 2.5 per cent, the loss in cathode heaters and a suitable control circuit totals 2.5 per cent. The apparent full load efficiency and no load loss compare favorably with the values for a rotating set.

Figure 6 shows the assembly of tubes and control transformers and Figure 7 the schematic diagram of the power and control circuits. Figure 8 shows a control panel containing control switches and means for insuring the proper heating time for the cathodes before voltage is applied to the anode. During non operating periods the cathodes are heated at reduced voltage to prevent mercury condensation on the anode or cathode. The control power switch is closed to apply full voltage to the cathodes and after the proper heating period an indication is given for the manual closing of the power switch which energizes the input power transformer. A manually operated control switch is used to change transformer taps under load through a pair of contactors to deliver the desired output voltage. In the operation of this converter, starting peaks or operating peaks during the day have been observed up to nearly 200 per cent load.

For many years endeavors have been made, not only to perfect the telephone so far as possible in the technical direction, but also to facilitate its operation and to make it an instrument offering the maximum convenience and comfort in use. In this direction an interesting development was described recently in the Siemens Review, published by Siemens & Halske of Germany. This development described a new telephone cord which is capable of stretching to over twice its normal length. This cord offers a practical solution to the difficulty of knotted cords which so frequently cause annoyance in the operation of the ordinary hand set.

The new cord is loosely plaited in the usual way from four insulated conductors while in addition an elastic rubber cord is run through the center which tends to pull the strands together. The expansion of the cord has been carefully calculated so that when the hand set is lifted and placed against the ear, the instrument remains stationary on the desk. The cord used is 55 cm. long in its contracted position and expands to 130 cm. The cords are very carefully made and tests have shown that they will last at least as long as ordinary plaited telephone cords.

Combustion Control

(Continued from p. 671)

an additional switch is provided so that the damper may be switched to manual control if desired.

This control may be used with any of the usual on and off starter controls, the interlock, however, must be ararnged so that the time switch, low water cutoff, overload and low voltage relays and other protective devices are not rendered inoperative. When provision for both manual and automatic stoker control is installed, the sequence control must be wired so it is effective with both.

All of the above controls have been referred to as working with stokers, although obviously they are equally well adapted for gas or oil firing. The latter problem is simpler because it does not involve refueling and the control reduces to pressure or thermostatic starting with the necessary pressure, temperature, pilot light and low water protective devices, and, with high draft, suitable interlocks to prevent blow back.

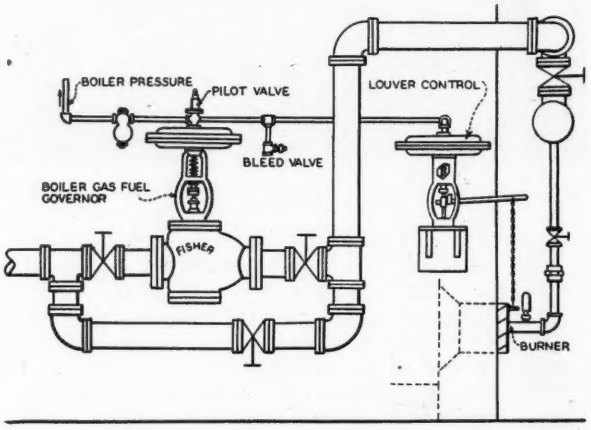


Fig. 9. Application of Fisher control valves to a small pressure controlled gas fired boiler

Control of these small gas fired boilers is, like on and off stoker control, becoming of constantly increasing importance as the natural gas distribution network spreads. The simplest arrangement is an electric or pressure operated gas valve. The diaphragm valve makes a good pressure operated controller for this purpose. In very small units the diaphragm may operate the valve direct but for larger valves and closer regulation, the pressure is made to actuate a pilot valve which in turn controls the valve movement through the medium of an operating pressure which may be steam, water or oil.

Fig. 10 shows one of the many controls made for this purpose by the Fisher Governor Co. The valve at the left is known as the Pilot Control Type 520. Steam pressure actuates the small pilot on the top to admit steam pressure to the diaphragm and operate both the gas valve and the burner air control louvers through the unit on the right known as Louver Control Type 522. This combination was developed for installations requiring close regulation but where air or water was not available or desirable as an operating medium and thus makes a rugged, accurate and self-contained control.

Refrigeration Compressor Capacity Calculation

An elementary analysis of heat exchange machine capacity and power requirements

By W. R. KITZMILLER

REFRIGERATION for preservation of food dates back into the early days of history. The first method of applying refrigeration was generally by harvesting and storing natural ice. The uncertainty of winter weather and the conditions of this ice gradually led to mechanical and chemical means of producing ice. The cost of the mechanical production of ice against the cost of natural ice was practically the same, so the number of ice manufacturing plants grew rapidly. The manufactured ice was cleaner, always uniform, and permitted easier handling. Ice does not lend itself to the solution of all cooling problems; hence we find today the conversion of electrical energy, coal or oil directly into means of cooling, freezing, processing, etc., directly by refrigerating machines.

The compression system shown in Fig. 1 is the one most commonly used today. In this the expansion valve feeds the liquid refrigerant into the evaporator as fast as it is boiled off. The evaporated gas is sucked out of the coils by the compressor and discharged into the condenser. The suction pressure will depend on the temperature desired in the evaporator or cooler. The discharge pressure will depend on the water or air temperature cooling the condenser. This cycle is continuous as long as cooling is required. The heat from the evaporator is actually transferred to the cooling water or air employed on the condenser, by changing the refrigerant gas back into a liquid. The amount of heat required to change the liquid into a gas, namely the latent heat per pound of refrigerant circulated, is the cooling effect secured.

Commercial Ton of Refrigeration

The work to be done by a refrigerant plant is generally expressed in tons refrigeration. The commercial ton of refrigeration is equal to the absorption of an amount of heat equal to the melting of 2000 lb. of ice per day, which is also known as the "heat of fusion" of one ton of ice. The round figure for heat of fusion of ice is 144 B.t.u. per pound, so the standard ton of refrigeration consists of removing 288,000 B.t.u. per day of 24 hr. This resolves into 12,000 B.t.u. per hour, or 200 B.t.u. per minute. The B.t.u. is equivalent to the amount of heat required to raise one pound of water one degree Fahrenheit.

The specific heat of water is considered to be 1 so all other substances must be related to water to find the tons refrigeration in cooling. The values of specific heat and latent heat for most substances can be found in hand books, after which it is only necessary to multiply the pounds, times the cooling range and the specific heat together, and divide the total by the number of B.t.u. corresponding to the time in which it is cooled. In lowering a substance below its freezing point the latent heat of that substance must be removed at its freezing point. For water this value is 144, most other substances it is practically its specific heat value times 144. If the substance is frozen and cooled lower in temperature the specific heat of the solid changes. For example, ice is 0.5 when water was 1.

Effect of Precooling

The total heat to be removed determines the tons refrigeration required to do the work. Ice illustrates this point nicely since the melting of one ton of ice per day determines the value of one ton of refrigeration, but about 1.6 t. refrigeration are required to produce one ton of ice. This factor varies for different water and surrounding temperatures so the actual amount of cooling work required to reduce the water to the freezing point, then remove the latent heat, and later sub-cool the ice, plus the insulation losses, totals approximately 1.6 T.R. per ton of ice using 75 deg. F. water. With 35 deg. F. water to the ice cans it is only necessary to employ about 1.33 T.R. per ton of ice so it is evident that pre-cooled water in the ice plant increases the efficiency of the plant. The pre-cooling can be done at higher suction pressure with less power per ton of refrigeration.

Ice is manufactured with a temperature in the

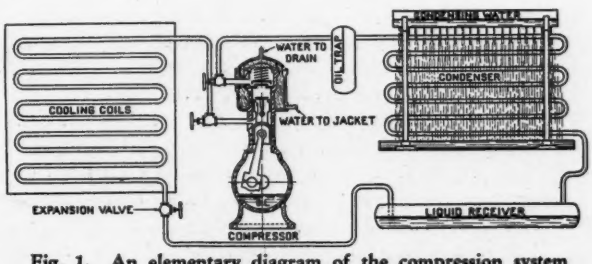


Fig. 1. An elementary diagram of the compression system refrigeration cycle

evaporator generally around 5 deg. F. The evaporator is surrounded with agitated brine which in turn flows past the ice cans in which the water is frozen. Many storages are cooled by an evaporating temperature of the same value but the evaporator is suspended in the room. In this way the heat from the product is transmitted directly to the air which comes in contact with the evaporator. The heat from the air changes the liquid refrigerant in the evaporator into a gas, consequently the liquid refrigerant absorbs the equivalent amount of heat. The difference in temperature between the refrigerant in the coils and the air in the room depends largely on the surface in the evaporator. The greater the amount of evaporator surface the smaller the difference between refrigerant and air and vice-versa.

Table I. Cubic feet of gas that must be pumped per minute to produce one ton refrigeration under different suction pressure conditions

Temp. of Suction	Suction Pres. Ga.	Cubic Feet of Gas Pumped Per Minute Per Ton Refg. at Following Liquid Temperatures —10°	0°	10°	20°	30°
—50° F.	14.3"	11.8	12.01	12.27	12.51	12.78
—35° F.	5.4"	7.64	7.78	7.93	8.11	8.28
—28° F.	0 lb.	6.31	6.44	6.56	6.70	6.84
—17.2° F.	5 lb.	4.78	4.86	4.96	5.06	5.16
—8.4° F.	10 lb.		3.92	4.0	4.08	4.16
5.5° F.	20 lb.			2.89	2.94	3.0

Temp. of Gas Deg. Fahr.	Suction Pressure Lbs. per Sq. Inch Gauge Pressure	Temperature of the Liquid in Degrees Fahrenheit. 65.9°	74.7°	82.5°	86.0°	89.7°	93.03°	96.3°	99.3°	102.3°	108°	113.3°
		Corresponding Condenser Pressure, Pounds Per Square Inch Gauge 105	125	145	154.5	165	175	185	195	205	225	245
—25.7	1	6.95	7.10	7.24	7.29	7.36	7.42	7.49	7.56	7.62	7.74	7.86
—19.2	4	5.88	6.00	6.11	6.16	6.22	6.28	6.33	6.38	6.43	6.53	6.64
—15	6.18	5.32	5.43	5.52	5.56	5.63	5.68	5.72	5.76	5.81	5.90	5.99
—10	9.05	4.68	4.76	4.87	4.91	4.96	5.00	5.04	5.08	5.13	5.21	5.28
— 5	12.22	4.14	4.22	4.30	4.33	4.38	5.42	4.45	4.48	4.52	4.60	4.67
0	15.72	3.68	3.76	3.84	3.86	3.90	3.93	3.97	4.00	4.03	4.09	4.15
5	19.58	3.28	3.34	3.41	3.43	3.47	3.50	3.52	3.55	3.58	3.63	3.69
10	23.81	2.91	2.97	3.02	3.04	3.06	3.10	3.13	3.15	3.17	3.22	3.27
14	27.49	2.68	2.73	2.78	2.80	2.83	2.86	2.88	2.91	2.93	2.97	3.01
19	32.51	2.40	2.45	2.50	2.51	2.54	2.56	2.58	2.60	2.62	2.66	2.70
21.4	35	2.28	2.33	2.38	2.39	2.42	2.44	2.46	2.48	2.50	2.53	2.57
25.8	40	2.08	2.12	2.16	2.17	2.20	2.22	2.24	2.25	2.27	2.31	2.34
30	45	1.91	1.95	1.98	2.00	2.02	2.03	2.05	2.06	2.08	2.11	2.14
33.9	50	1.77	1.80	1.84	1.84	1.87	1.88	1.90	1.91	1.93	1.95	1.98

The above values are based on a saturated gas reaching the compressor suction. This is not always possible but under normal operation the amount of superheat in the gas is negligible. However, where high amount of superheat is to be expected the volumes above will increase. The correct liquid volume in cubic feet per pound can be found under "superheat tables" in most of the references given for ammonia tables. Normally ammonia is operated as near saturation as possible since the efficiency is the best at saturation. In the lower temperatures this is not true of one of the so-called "low pressure refrigerants," and, in this case, superheat from liquid cooling actually increases the capacity slightly.

With the advent of air conditioning the question of machine sizes has often arisen. A freezer may operate with —28 deg. F. refrigerant, an ice tank with +5 deg. F. and an air conditioning system with +40 deg. F. Since the same compression system is used in all cases the question arises as to the relation between these conditions. The power required per ton refrigeration at the low temperatures is higher than at the high temperatures. That is, an ammonia compressor developing 1 T.R. at —28 deg. F. requires 2.7 br.hp. or 2.7 br.hp. per T.R. This same compressor at +5 deg. F. would develop 2.55 T.R. and requires 3.9 br.hp. or 1.52 br.hp. per T.R. Under 40 deg. F. it would develop 5.9 T.R. and requires 4.4 br.hp. or 0.74 br.hp. per T.R. This same relation continues decreasing at the high temperatures and increasing at the low temperatures.

It is immediately evident that the least power per ton refrigeration is required at the highest suction temperatures. This is true with any refrigerant so plenty of cooling surface should be provided at all times to permit operation at the highest practical refrigerant temperature. Proper refrigerant control is essential so the best opeating results can be secured. It is also absolutely necessary to provide the proper size compressor to maintain the desired operating conditions. The oversized machine is to be preferred, as with it temperatures can always be assured. Experience, however, must dictate this value to be certain that the compressor is not sufficiently oversized to cause inefficiency by operating at a lower suction pressure than required. For highest efficiency it is always necessary to do as much work at high suction pressure as possible, which accounts for the increasing demand for booster and compound compression systems. With both of these systems the liquid is often cooled at the high suction pressure, the same as for any other high temperature work. Such an arrangement of two systems handles the gas in two stages, otherwise identical to the simple compression system, Fig. 1.

Ammonia Tables

Compressor capacity is often a source of discussion due to the standard rating under which it may have been originally sold. If the compressor was moved or operated under other conditions the capacity and horsepower problem will arise. An analysis or survey of an ammonia compressor problem may be used to determine these conditions. First it is necessary to have an ammonia table or the "Thermodynamic Properties of Ammonia," obtainable from the government printing office, as Bureau of Standards, Circular 142 or in any of several hand books, including the A.S.R.E. "Refrigerating Data Book."

We will assume for our problem the displacement or "swept volume" of the compressor is known to be 100 cu. ft. per min. We will figure the capacity at +5 deg. F. suction temperature (which corresponds to 19.6 lb. ga. pressure) and 86 deg. F. condensing temperature (which corresponds to 154.5 lb. ga.). Referring to the ammonia table:

Table II. Average values of mean effective pressure of compressor cards at different condensing and suction pressures

Suction pressure lb. gauge	Condenser Pressure Pounds Gauge 105	125	145	154.5	175	185	205	225
0	39.2	43.2	45.7	46.8	48.8	50.0	52.0	53.7
1	40.3	44.3	47.3	48.5	50.6	52.0	53.9	56.0
3	42.0	46.4	49.3	51.0	53.4	54.6	56.9	59.5
5	44.1	48.6	51.4	53.1	56.0	57.7	60.5	62.5
10	46.9	52.3	56.3	58.4	61.8	63.5	66.8	70.2
15	49.3	55.3	59.9	62.4	66.5	68.4	72.7	76.2
19.58	50.6	57.5	62.6	65.3	70.5	72.6	77.4	81.2
25	51.6	59.3	65.5	68.7	74.2	76.5	81.7	86.5
30	51.5	59.7	67.1	70.5	76.6	79.8	85.0	90.4
35	51.1	59.8	67.9	71.5	78.5	81.5	87.6	93.5
40	50.2	59.2	67.8	72.0	79.9	83.3	89.7	96.0
45	48.4	57.7	67.5	71.5	80.0	83.7	91.1	97.5

It should be noted that M.E.P. values under each condensing pressure increase up to a certain point after which they start to decrease. This maximum value occurs under each condensing pressure at a different suction pressure, dependent on the compression ratio to a certain extent. It is now further evident why the br.hp. per T.R. decreases with increased suction pressure under the same condensing pressure.

613.3 B.t.u. per pound is the heat of vapor at 5 deg. F. suction
138.9 B.t.u. per pound is the heat of liquid at 86 deg. F. discharge

474.4 B.t.u. per pound is the useful heat or the refrigerating effect.

After finding the useful heat per pound it is necessary to find the number of pounds of refrigerant in

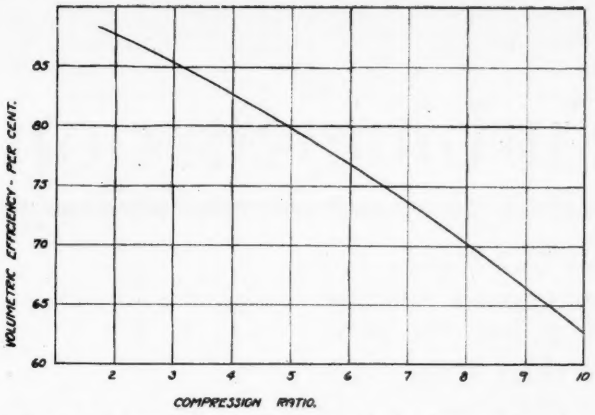


Fig. 2. Volumetric efficiency varies with the compression ratio

circulation. This can be done by finding the number of pounds per ton refrigeration and then multiplying by the T.R.

$$\frac{\text{200 B.t.u. per minute standard ton}}{\text{474.4 B.t.u. useful refrigeration effect}} = \text{0.422 lb. of ammonia per ton per minute.}$$

When finding the capacity of a compressor it is necessary to find the cubic feet per minute per ton refrigeration, that is multiply the pounds per minute by the volume of gas per pound under the operating conditions. Thus 0.422 lb. $\times$ 8.15 (cu. ft. per lb. at 5 deg. F. suction, vapor volume from the tables) equals 3.43 cu. ft. per min. per ton refrigeration. Necessary volumes for different conditions are tabulated in Table I.

The displacement of the compressor must be decreased by the "Volumetric Efficiency" which depends on the operating conditions and varies for different pressures. It depends almost entirely on compression ratio, the high pressure divided by the low pressure, in absolute pressure which is gage pressure plus 14.7. In this case it is

$$\frac{154.5 + 14.7}{19.6 + 14.7} = 4.93$$

Figure 2 illustrates average volumetric efficiences for various compression ratios. These values are based on some of the present day high speeds but include late designs which as the general rule give average values, compensating for the older slow speed. The volumetric efficiency in general allows for the compressor cylinder losses; that is, wall heating, valve leakage, and piston ring loss. The values given in Fig. 2 are of no particular design but cover volumetric efficiency in general. For our problem this value is about 80 per cent. So

$$(100 \times 0.80) / 3.45 = \text{23.2 ton refrigeration as the capacity of the compressor.}$$

Under some conditions the liquid fed to the expansion valve is cooled below the condensing temperatures by some outside means, as mentioned above. This will increase the capacity of the compressor by reducing the quantity of liquid ammonia handled per ton, due to the decrease in heat content of the liquid. The principle of our example above remains the same, but the heat of the liquid should be taken at the temperature to which it is cooled. The dual suction pressure compressor is an exception since it will handle two pressures, namely a low suction pressure and a high suction, which are both compressed to condensing pressure. In this way the dual pressure compressor cools water and liquid, especially for ice plant service, at the high suction pressure and manufactures ice at the low suction pressure. The calculations for the dual pressure compressor differs slightly from that given above, since the liquid cooling must be taken into account and the suction volume remaining at the high pressure, to do its work, must be calculated. This volume varies with the different pressures but will always balance out with a 5 to 15 per cent power saving over straight compression.

In finding the power required to drive the compressor illustrated in our problem above it is necessary to figure the mean effective pressure and use the formula:

$$\text{Horsepower} = \frac{\text{PLAN}}{33{,}000} \times \text{No. of cylinders} \times (1 + \text{friction of 12 to 15\%})$$

P = mean effective pressure
L = length of stroke in feet
A = area of cylinder in square inches
N = revolutions per minute of compressor

The mean effective pressure can be found from the theoretical indicator card laid out for the operating conditions, a formula, or actual practice. The total horsepower can also be found by determining the heat of compression from the Mollier diagram per pound of refrigerant. Since the number of pounds of refrigerant in circulation per minute would be known, multiply by the heat of compression per pound times 0.02356 which will give theoretical horsepower. It is, however, difficult to know what increase over theoretical horsepower should be used, at times, for practical drives so the M.E.P. (from actual practice) substituted in above formula is the best. The M.E.P. values vary according to a number of different things so the values given in Table II give average values which can be selected for a number of different operating pressures. These values are taken from a vertical machine test where the speed will help to compensate for the clearance of horizontal compressors making these values about average. In our case this value is 65.3 and since LAN times the number of cylinders is nothing more than the displacement multiplied by 144 we have:

$$\frac{100 \times 144 \times 65.3 \times 1.12 \text{ (friction)}}{33{,}000} = \text{32.2 Br.hp.}$$

A certain margin is allowed in selecting the motor or engine to compensate for unusual operating conditions, losses in the drive (unless direct connected), etc. In case of automatic electric control, a high torque motor is used to eliminate difficulties in starting. The refrigerant can be controlled automatically in many different ways with the devices now available.

Refrigeration has shown a remarkable growth in the past few years and the developments in air conditioning and process work present many interesting problems. Anyone operating refrigerating machinery or purchasing equipment should secure the latest literature and a copy of some reliable hand book.

Small Steam Turbine Station

1000 kw. Combination Back Pressure and Condensing Turbine operates 100 per cent unattended in large industrial plant

By XENOPHON D. IDES
Consulting Electrical Engineer,
Philadelphia, Pa.

IN ORDER to provide a better plant heat balance, as well as large degree of flexibility in the automatic control of the liquids circulated in a new process recently installed in a large industrial plant, steam at 175 lb. pressure was selected as the motive power. To better utilize the heat content of the large quantities of steam required at full load, approximately 25,000 lb. per hr., it was further decided to operate all steam engines and turbines at 40 lb. back pressure, and then to pass the exhausts through a condensing waste heat turbine, making whatever electrical power could be generated available for use throughout the plant. The use of such an arrangement was considerably encouraged by the fact that a plentiful supply of condensing water was also available from the discharges of a number of cooling units required for the proper operation of the new process.

On account of the distance of the new installation from the main power house which was approximately 1750 ft. away, the use of an induction generator with its simplicity of control was given serious consideration. The existence in the plant, however, of a number of infrequently used turbo-generators, any one of which could be readily moved to the new location and modified to operate under the new conditions, offered considerable economic advantages, and was therefore decided upon. For this purpose, a 1000-kw., 0.8 p.f., 2300 v., 3600 r.p.m., 3 phase, 60 cycle, turbo-generator unit with a direct connected exciter, operating up to that time at 175 lb. and 20 lb. back pressure, was therefore selected, and arrangements made to have the turbine rebladed and changes made to its governing mechanism.

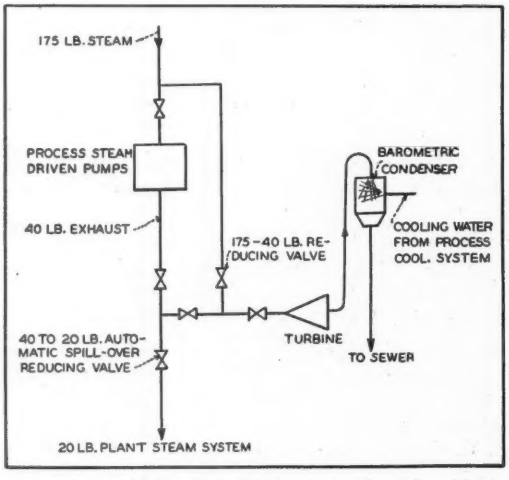


Fig. 1. Diagram of the steam system

The presence of inflammable gases in the buildings accommodating the various pumps and compressors, made the installation of the turbo-generator unit in their immediate vicinity entirely out of the question, and it was therefore decided to provide suitable housing by the erection of a small building some 200 ft. away from the process area which was considered quite safe. This building was also arranged to house the necessary control panels, the 2300 v. generator and feeder switching structure, as well as all the other electrical equipment required for the proper operation of this miniature power plant. To justify the expenditures for such an installation, it was quite obvious from the start, that all operating personnel should be eliminated, and the station was therefore designed on this basis, the layout incorporating a sufficient number of protective features so as to prevent damage to generator or turbine under abnormal conditions. Since the process steam requirements were to be of a continuous nature and comparatively small variations over long periods of time, it was considered quite satisfactory to have an operator from the main power plant connect the generator to the line through the usual manual synchronizing method, after which the station doors would be locked, and the unit left to itself.

In order to provide a maximum amount of flexibility in the operation of this turbo-generator unit, the main steam connections were arranged as shown in Fig. 1. It will be noted, that the exhaust steam from the process pumping equipment may be used wholly by the turbine, or made to spill over into the plant's 20 lb. system through an automatic 40 to 20 lb. reducing valve. In a similar manner, 40 lb. live steam in any quantities required may be obtained through a 175 to 40 lb. reducing valve to make up for deficiencies in exhaust steam from the process when operating under reduced output or independently from it. The exhaust steam from the turbine is condensed in a barometric condenser supplied with water from the cooling system of the process, the mixture then discharging into the plant sewer. Turbine loading is obtained through

Operates Entirely Unattended

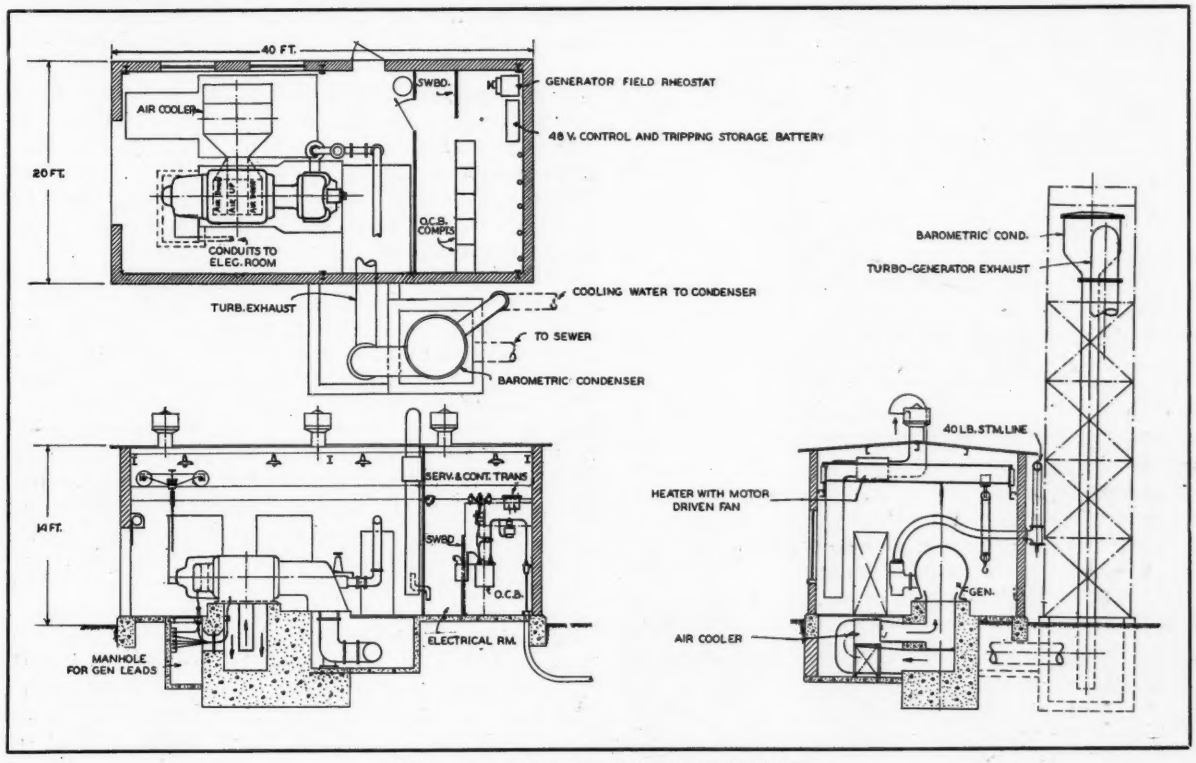


Fig. 2. Plan and sectional elevations of building

the action of a waste heat governor, and turbine protection through the actuation of an electrically operated throttle trip, an overspeed trip, and a casing pressure trip, acting through the generator emergency trip system as will be described later. Provision has also been made to sound an alarm at the main power plant and identify the cause of the trouble through the use of an annunciator board, when bearing and oil well temperatures exceed a safe value, as well as when the turbine exhaust piping condensate discharge system becomes flooded and fails to operate properly.

The details of the station are shown in Fig. 2. The generator main, field and exciter leads and the stator exploring coil temperature leads from the electrical room to the unit are run underground in conduit encased in concrete, and pass to their destination on the generator through a hermetically sealed water-tight manhole located directly under the exciter. All the other control and temperature wires, such as the governor control, throttle trip, and miscellaneous temperature are also run in underground conduit groups terminating in two galvanized cast-iron, water-tight junction boxes located on the walls of the two trenches, and thence are continued in exposed conduit to their respective destinations.

The generator has been connected to the mid point of a 400,000 c.m., 3300 ft. long line from the main power house to one of the larger pumping stations in the plant, as will be noted by referring to Fig. 3, and under normal operating conditions, most of the output from this unit is supplied to the pumping station. A 2300 v. insulated bus mounted on a suitable pipe structure framework in the electrical room of the station forms part of the line connecting the main power house with the pumping installation, the connections of the incoming and outgoing cables to this bus being made through sectionalizing disconnecting switches only. Provision, however, has been made, for the installation of oil circuit breakers in these disconnecting switch bays, should such an arrangement be considered desirable in the future. This 600,000 c.m. bus, also provides power through an OCB-controlled feeder, to the process substation located 400 ft. away, and provision has been made for the future installation of a similar feeder to supply additional power requirements in this vicinity. There is also space on the 2300 v. structure for a third feeder, which however, can be equipped only with high power interrupting capacity fuses of the disconnecting switch type. The generator and feeder oil circuit breakers used are of the motor operated type, and have a rupturing capacity of 20,000 amp. at 2300 v. Operation of the motor mechanisms is

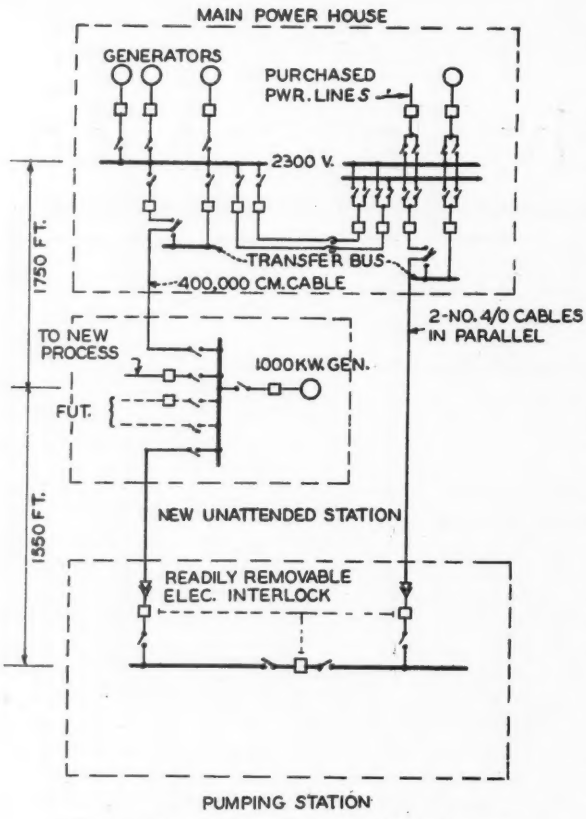


Fig. 3. Schematic diagram of the electrical system

obtained from a 2300 to 230 v. distribution transformer connected to the bus through disconnecting switch type fuses having high power interrupting capacities. Tripping and miscellaneous relay operations and indications are obtained through the use of a small 48 v. storage battery connected to a trickle charger.

The control of the various circuits involved is brought about by the use of two sets of switchboards, one of these being located at the unattended turbogenerator station, and the other at the main power plant, approximately 1750 ft. away, where 24 hr. attendance is to be had. All interconnecting wiring consists of No. 19 telephone wires in two 26-pair, high dielectric, paper insulated, lead covered cables installed underground. One of the cables is used for the a.c. and the other for the d.c. circuits. The various circuits are provided with both local and remote metering instruments, as well as remote and local control. To obtain remote metering on the indicating and graphic a.c. instruments through the use of the telephone cables, the 2300 v. structure current transformer secondary currents are still further reduced at the local board by the use of an additional set of current transformers having a rating of 5 to 0.1 amp. Potential transformer secondary currents are impressed on the telephone wires without any reduction in their potential of 115 v. All the a.c. instruments, except the watthour meters, at the remote panel have 0.1 amp. current and 115 v. potential coils. Inasmuch as at the time the project was under construction, no watthour meters had as yet been developed capable of operating at these reduced currents, it was decided to install the standard instruments, and to supply their 5 amp. coils through current transformers having a 0.1 to 5 amp. rating.

To protect the telephone cables against excessive voltages which might be developed both in the current and potential transformer circuits, use was made of devices utilizing a gas filled tube designed to discharge at 250 to 300 v. r.m.s., and connected in the circuit as shown in Fig. 4. It will be noted, that taps from the two ungrounded wires in each circuit are connected to the two live terminals of the tube. A third set of terminals connects to the ground wires of the circuit. The initiation of a discharge which is brought about by an excessive voltage is followed by ionization of the gas sufficient to pass 50 amp. for 2 sec. The telephone wires are connected to the current and potential transformer circuits through fuses, which by blowing, isolate the cable from the defective equipment. The 5 to 0.1 amp. current transformers are designed so as to withstand without any damage an open circuit in their secondaries.

Remote control of the oil circuit breakers, of the field rheostat, and of the emergency multicontact trip relay, is accomplished by the use of intermediate telephone relays equipped with mercury contacts. Since the generator is synchronized through the local switchboard, control for the motor operated governor is provided only at the local panel. The same is true of the generator OCB closing circuit. Provision, however, has been made for both local and remote field control, as well as emergency generator OCB tripping, which simultaneously also shuts off the steam supply from the turbine. Such an occurence builds up the pressure in the steam supply line from the process installation, which, however, is immediately relieved through the action of the spill-over valve discharging into the 20 lb. steam system of the plant. A system of interlocks has been provided on the main and transfer bus OCB closing circuits at the main power house, preventing their closure if the generator OCB is closed. Closing and tripping control of the feeder OCB at the unattended station supplying the new process installation is provided on both the local and the remote panels, however, in order to reduce any disturbances which

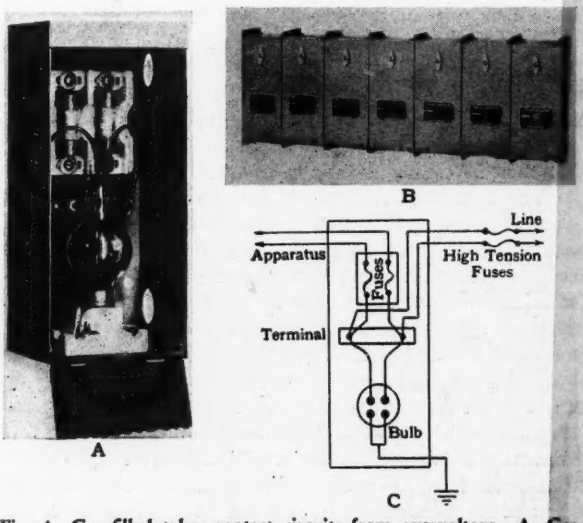


Fig. 4. Gas filled tubes protect circuits from overvoltage. A. Gas filled protector unit assembly. B. Typical method of assembling a number of units. C. Typical wiring diagram

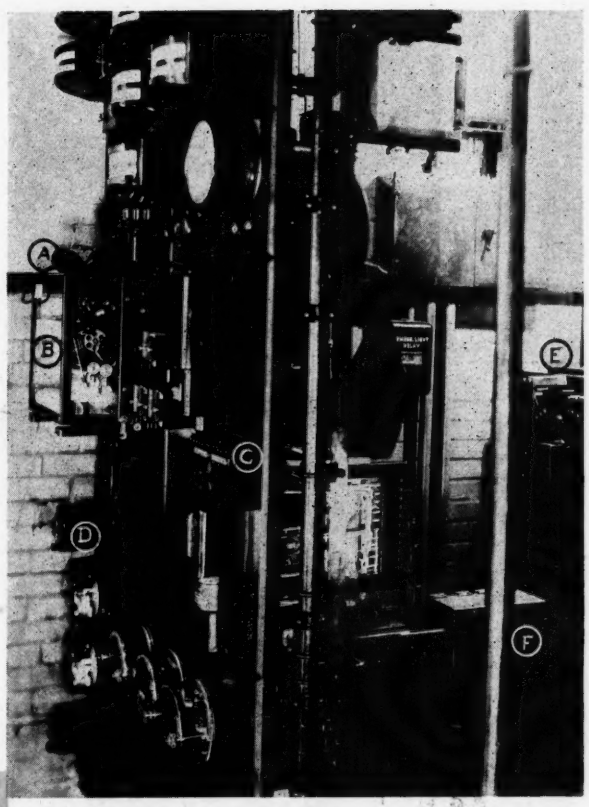


Fig. 5. View of panel in unattended station. A. Anti-noise Telephone. B. 8 Point temp. recorder. C. Alarm Circuit Test Buttons. D. Telephone Relay. E. Gen. field rheostat. F. Tel. wire vacuum tube overvoltage protector cabinets

might be caused to the power system by the repeated closing of this breaker on shorts by the operator at the main switchboard, a lockout feature was incorporated in its closing circuit, permitting only one closing after the first operation of the overload relays. The unsealing of this locked circuit can be brought about only by the operation of a button at the local panel, which of course, presupposes that a competent party has been sent to the field to investigate the cause and possibly clear the trouble. Telephone relays, operating in conjunction with the standard induction overload relays are used in this circuit.

The local switchboard at the turbo-generator station consists of two 24 in. panels, Figs. 5 and 6, with space reserved for the future installation of a third similar panel if ever required. These panels accommodate all of the generator and feeder indicating instruments, the various protective relays, the manually operated but electrically tripped field breaker, the multi-point temperature recorder, and miscellaneous control devices and telephone relays. The duplicate set of indicating instruments at the main power plant, Figs. 7 and 8, are mounted on a 24 in. panel occupying the space previously used for the control of the generator which was moved to the unattended station. This panel, in addition to the remote controls for the generator and two feeders, also accommodates the controls, instruments and relays for the OCB controlling the tie line from the main power house to the new station. A graphic record of the generator output is obtained through a recording wattmeter, and the bottom section of the panel has mounted on it five watthour meters, two of which are ratcheted for the tie line circuit. Space is available for a future sixth watthour meter if ever required. The rear of the panel, Fig. 8, provides space for a variety of telephone relays mounted on suitable brackets, the induction overload relays for the tie line, the 0.1 to 5 amp. current transformers, and miscellaneous resistors and terminal blocks. The two telephone cables at the two stations are terminated in the Western Electric Co.'s Type C cable terminals, from which the necessary wiring is continued to the various points on the panels, as will be noted by referring to Figs. 6 and 8.

No effort was made to transmit temperature readings from the generator and other points at the new installation to the switchboard at the main power plant. To obtain the proper protection for the equipment, however, an 8 point temperature recorder with an adjustable high point alarm contact was installed on one of the local panels, Fig. 5, and the contact from this point was arranged through suitable telephone relays to give an alarm and to light a small telephone lamp on the annunciator board located on a panel at the main switchboard directly in front of the operator's desk, and shown in Fig. 9. Another continuously lighted lamp on the same annunciator panel, indicates to the operator that the temperature recorder is running, the stoppage of its motor being accompanied by the extinction of this light and the simultaneous sounding of an alarm. The temperature recorder has been connected to resistance type exploring coils at the fol-

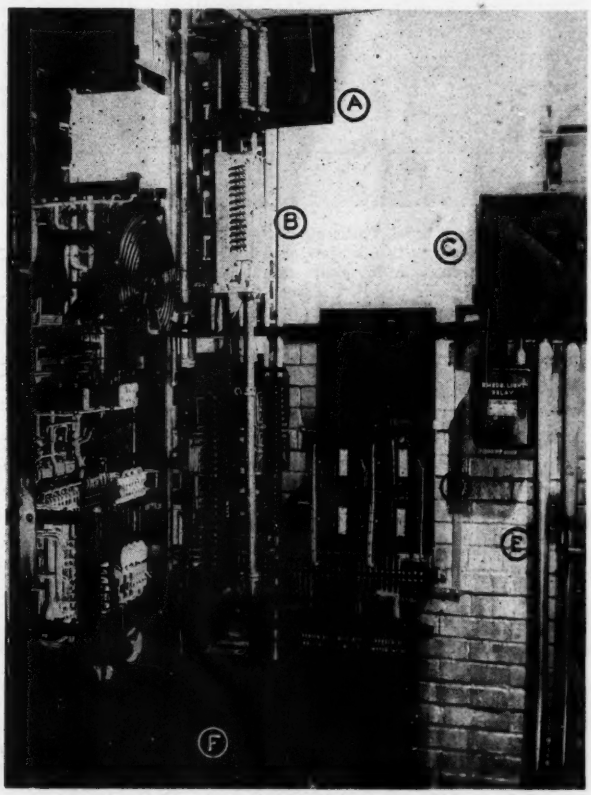


Fig. 6. Details of rear of panel at unattended station. A. Battery charger. B. 26 pair tel. cable terminal block and tel. cable. C. Misc. service circuit distribution box. D. Current transformers. F. Gen. field rheostat handle. F. Vacuum tube overvoltage protectors

lowing points: 1. Generator stator coils. 2. Generator rotor coils. 3. Turbo-Generator lubricating oil well. 4. Cooling air into generator. 5. Heated air from the generator. 6. Exhaust steam temperature at condenser. 7. Generator air cooling water out. 8. Condenser cooling water in.

Electrical protection for the generator was further provided by the use of induction type overload relays,

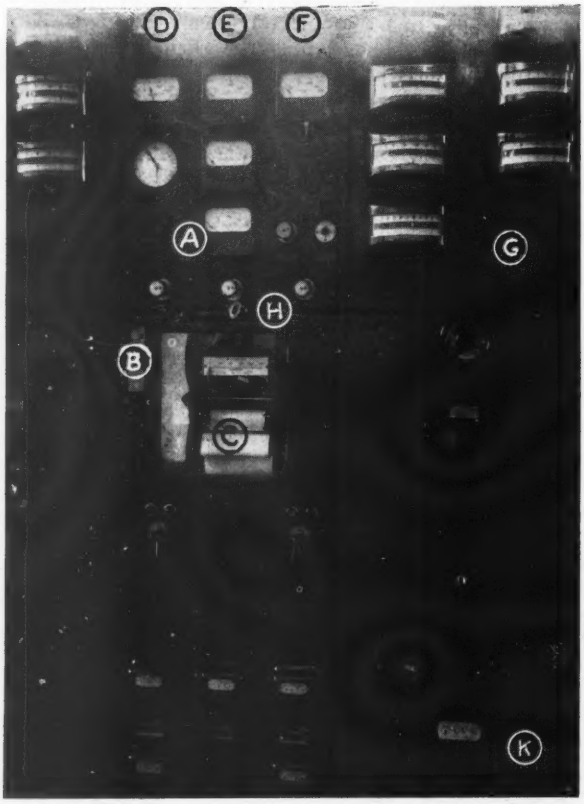


Fig. 7. Control and Instrument Panel in Main Power House. A. Gen. emergency trip button and field ammeter. B. Tel. relays. C. Graphic wattmeter for generator at isolated station. D. Station tie line. E. Generator. F. Feeders. G. Wattmeter transfer switch. H. Anti-noise telephone and jack. K. Watthour meters

a reverse power relay, and a field or exciter undervoltage relay. The operation of any one of these devices in turn energizes a manually reset multicontact relay which trips the generator oil circuit breaker, the generator field breaker, the turbine throttle, sends an alarm and lights the proper lamp on the annunciator board at the main power house, and lastly opens its own circuit after it has once operated. Since the new station is unattended, and considerable time might elapse between the shut down of the turbine and the arrival of competent help from the main power house, a mercoid pressure switch was installed on the turbine side of the throttle valve so as to shut off the supply to the throttle tripping solenoid, thus preventing unnecessary drainage of the small 48 v. storage battery. Bearing protection is obtained by the use of bellows type thermostatic relays installed at each one of the three main bearings of the unit. The actuation of any one of these three relays the contacts of which are connected in parallel, causes an alarm to be sounded at the main switchboard, the identification being made by the light on the annunciator board. The closing of the various temperature and condensate level alarm contacts does not initiate the tripping of the turbo-generator, but since the operator at the main power house has control over this operation through the use of the emergency trip button, he can very easily remove the unit from the system, if he feels that this should be done, or is instructed to do so by his superiors.

An extensive use has been made of telephone relays and equipment, not only for controlling the field rheostat, the oil circuit breakers, and other relays, but also for providing the various alarms and indications at the main power house. Even the annunciator board for identifying these alarms has been constructed from

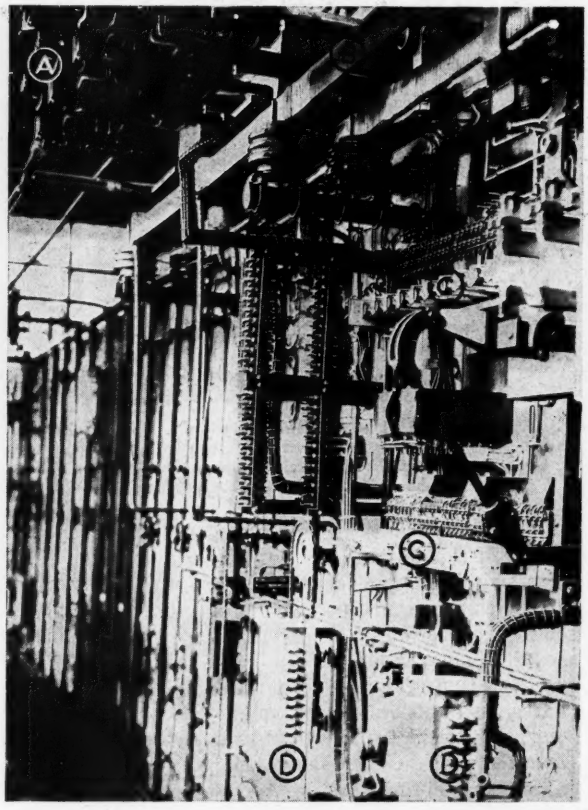


Fig. 8. Rear view of new and old panels in main power house. A. 0.1 to 5 amp. current trans. B. Exciter bus (old installation). C. Telephone relays. D. 26 pair tel. terminal blocks

telephone lamp socket mountings and similar push button and designation strips mounted directly below them. The operation of the key or button directly below the identifying light provides means for automatically stopping the ringing of the alarm bell without at the same time extinguishing the light. This latter indication, however, automatically goes out at the opening of the initiating alarm contacts at the isolated plant, this opening also simultaneously resets the alarm circuit relays, which are now in position to function and give the alarm at the next occurrence of the undesirable condition. Four such groups of telephone switchboard equipment providing a total of 40 independent circuits for present and future use, has been assembled in a metal case with a hinged back, and has been mounted on a switchboard panel directly in front

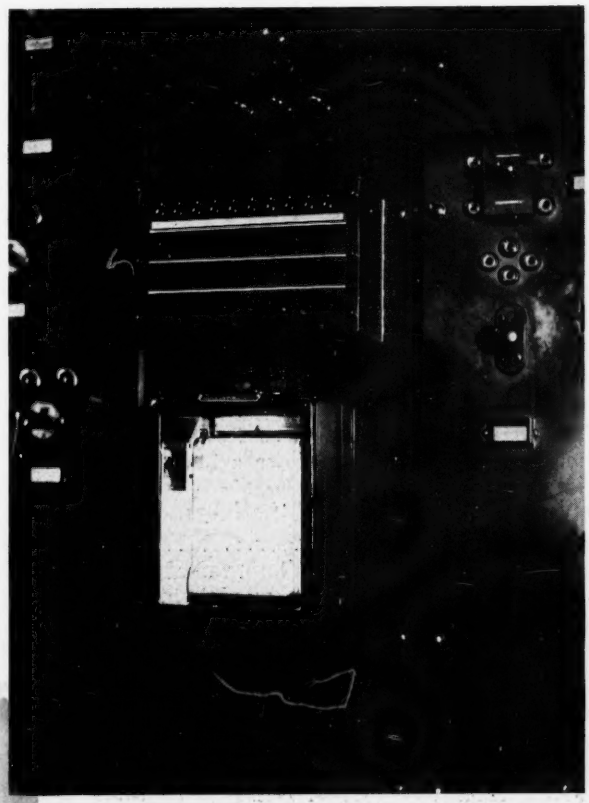


Fig. 9. Annunciator Panel. Total ultimate capacity, 40 ccts.

of the operator, see Fig. 9. As will be noted, the annunciator board occupies the very small space of 8 by 12 in. In order to facilitate the periodical testing of the alarm relay circuits, each alarm sending contact has been shunted at the local board with a telephone type push button. If the alarm circuits are in good condition, the pressing of any one of these buttons rings the alarm bell and lights the proper lamp at the main power house switchboard, and in turn confirms this operation by ringing a bell at the local board.

Telephone communication between the two switchboards when required, is obtained by the use of a direct line through the multipair control cables and the use of anti-noise telephones. Each one of these units is connected to a plug, the insertion of which in the jack at either panel automatically rings the alarm bell and lights a distinctive lamp at the called point. The insertion of the plug in the jack at this latter point immediately shuts off the alarm and conversation can be carried out between the two points very clearly despite all the noise of the adjoining turbines and generators. Another very interesting use to which the telephone cables have been put is their use in connection with steam flow metering both of the steam used at the unattended station as well as at the new process, a total of four such circuits have been installed so far with recording and integrating steam flow meters located at the new process control room as well as at two points in the main power plant.

In concluding, the author wishes to state, that this unique and remarkable installation was conceived and engineered by Wm. T. Sherman, consulting power engineer.

Low Temperature Phenomena

AN INTERESTING discussion took place recently on Supraconductivity and other low-temperature phenomena under the auspices of the Royal Society in England at which the opening address was delivered by Professor J. C. McLennan, F.R.S. This address presented an excellent survey of the present position of the subject and was reported in Engineering of London, from which the material here has been abstracted.

According to Professor McLennan, until 1923 liquid helium had only been produced in Leyden but it is now obtainable in laboratories in the United States, Canada, England, Germany, the U.S.S.R. as well as in Holland.

Since 1932 two notable advances have been made in the design of apparatus for the production of liquid helium and it is now produced at low cost although in very small quantities by a discontinuous process in which the cooling was produced by the adiabatic desorption of helium gas from charcoal.

The lowest temperature which had been reached with liquid helium alone was 0.71 deg. K., but a method had recently been developed for reaching a much lower temperature. This was based on the cooling effect obtained under certain conditions by adiabatic demagnetization. In 1926 Debye showed that it would be possible to get a measurable cooling effect with paramagnetic salts if the initial temperature were sufficiently low. This method has been found to be highly efficient. In applying it, the salt was cooled in the presence of a magnetic field of about 30,000 gauss to a temperature of about 1.26 deg. K. by the use of liquid helium under low pressure. It was then thermally insulated and under these conditions the magnetic field was suddenly reduced to a fixed low value of a few hundred gauss or even less. Adiabatic demagnetization of the salt ensued and, as a result, its temperature was lowered. The salt itself indicated by its magnetic susceptibility the temperature reached. By using this method with potassium-chrome alum, de Haas, in February of this year, attained a temperature of 0.0044 deg. K.!

Another field of activity in low temperature research in which considerable work has been done is that connected with the phenomena of supraconductivity. It is quite well known that when temperatures of certain materials, such as lead, mercury and others, is reduced to an extremely low value within a degree or two of absolute zero, the electrical conductivity becomes enormous, in fact all resistance seems to vanish and if an electric current is induced in the conductor when in this state it will persist for hours and days without any apparent diminution and without the application of an external electromotive force. It has long been disputed, however, whether supraconductivity should be considered as a general property and whether all metallic elements would show the phenomena at sufficiently low temperature. The new method of attaining very low temperatures referred to above by demagnetization promises a closer approach to the answer and investigations in this direction are in progress.

As One Engineer to Another—

The Degree-Day and Radiation from Building Keep G. F. and The Chief Busy for a Half Hour

By G. F. WETZEL

"WELL HERE you are again," the Chief greeted, "and with cold weather freezing up pipes and tenants continually complaining about cold drafts, I have had plenty of experience to make me realize I need a lot of information from that book of yours. We certainly are getting plenty of radiation from this building, judging from the amount of fuel we are burning and I for one would like to prove to the Boss that we are using no more fuel than is necessary to care for the radiation from this old building."

"Now that is just fine," I replied, "but you are not going to get me to work out your special problem, things don't come that easy. You're going to work out, shall I say, a hypothetical problem and then you can apply the principles to any problems you may have.

"Before you can find the radiation, the building or room heat loss must be known, so let's look into that. Think of a building, during the heating season, as just a large box with warm air at the desired temperature inside, while outside air is at varying temperatures from the coldest, say 25 deg. below zero, to a 24-hr. average of 65 deg., which is the basis used in figuring degree-days."

"Wait a minute, G. F. I've heard that term 'degree-days' before but never was clear on just what it means," said the Chief.

"A 'degree-day'," I answered, "is the unit used to measure heating requirements due to the outdoor temperature. The number of degree-days for each day is the number of degrees the 24 hr. average temperature is below 65 degrees.

"But here,—we are getting off the track. Come back to building heat losses. We have a volume of warm air separated by walls, windows, doors, and roof, from much colder air. Naturally there will be a heat flow from the warmer to the colder temperature. If a given temperature is to be maintained, whatever heat is lost must be replaced, and this constitutes the heating load. This depends on three factors and is given in B.t.u. per hour:

(1) The heat required to offset the heat transmission of the walls, ceiling, roof, and floors (including windows and doors);

(2) The heat required to warm the air entering the building from the outside, which may enter by infiltration or be introduced for ventilation.

(3) Minus the heat supplied by persons, lights, machinery motors, etc.

The last factor should only be deducted when the nature of the building is such that it is extremely unlikely that there will be any changes from the original use or occupancy.

"The heat lost by transmission depends on the nature of the materials used in the walls, roofs, etc. This loss is given in B.t.u. per square foot per degree difference in temperature between inside and outside air, per hour (B.t.u./sq. ft./deg./hr.). In the little red book (the A.S.H.V.E. Guide, and not so little either) there are tables giving the transmission rates for every kind of wall and roof construction in common use. We might put down a few to give you an idea of how they run:—

Construction	U Factor
12 in. solid brick wall	0.36
Same, with plaster on wood lath, furred	0.24
2 by 4 stud wall, plaster on wood lath, wood siding	0.25
Flat roof, no ceiling, no insulation, 1½ in. wood deck and joists	0.37
Same, with lath and plaster ceiling	0.26
Windows, single glass	1.13
Solid wood door, 2 in. thick	0.46

"U" is the symbol generally used to represent the factor giving B.t.u./sq. ft./deg./hr.

"The heat loss occurs through the heating of the walls by radiation and convection, the conduction of heat from the inner to the outer surface, and the cooling of the outer surface by radiation and convection. All that is necessary is to get the wall area for each type of construction in a given building, the window area, roof area, and area of any other wall or floor with unheated or partially heated space on the other side. Then find the correct coefficient for each wall, etc. Area multiplied by U (the transmission factor) then by temperature difference, gives transmission heat loss in B.t.u. per hour. Put in formula form:—$H_t = A \times U \times (t_i - t_o)$

where A is area in square feet

H_t is heat loss due to transmission through walls, etc.

t_i is inside temperature

t_o is outside temperature

Repeat for windows, roof, and any other heat transmitting area,—add all together and you will have the total transmission loss.

"Next is the second factor, the heat carried away by the air. In every building there will be air changes, one air change being the volume equivalent to the volume of the building or room, this air having to be warmed from outside to inside temperature. In the absence of a ventilating system there will usually be from one to three changes per hour. These changes are brought about by the natural wind velocity forming a slight pressure on one or two sides of a building, and the difference in density due to the difference in temperature, the outside air entering through cracks around doors and windows or porous construction, and the inside air leaving on the opposite side or sides."

"You mean to tell me that enough air can come in through the cracks around the windows to make even one air change per hour?" the Chief asked skeptically.

"Naturally, the ratio of window perimeter to volume of room will have something to do with it, but in general, it works out that way. According to the A.S.H.V.E. Guide, for a double hung window with 3/16 in. crack and 3/64 in. clearance, the infiltration of air, for a 15 m. per hr. wind velocity will be 39.3 cu. ft. per hr. per foot of crack. The 'crack' sizes given refer to 'crack' as the edge clearance and the 'clearance' as total difference between width of guide-groove and sash-thickness, and are the average sizes found from measuring over 600 windows during the heating season. For a 3 ft. by 6 ft. window, there would be $3+3+3+6+6$ or 21 ft. of crack, giving

21×39.3 or 825.3 cu. ft. per hr., for one window. (The extra window width is the crack at the meeting rails of the window.)

"There are two methods used to figure the volume of air to be heated per hour. One, estimate the number of air changes per hour; two, compute the infiltration, using all the crack in one exposed wall, with two exposed walls, the one with the greatest amount of crack, with three or four exposed walls one-half of the total amount of crack, then multiply total crackage taken as above by the volume per linear foot per hour. It really is comparatively simple. To find heat required by the air, just use our old friend the heat quantity equation,

$$H = W \times C\ (t_1 - t_2)$$

where H is a heat quantity
C is specific heat
t_1 is the higher temperature
t_2 is the lower temperature

Notice that we get the volume of air from either the air-change method or computing from crackage, and that the formula uses weight, so we will have to change volume to weight. 1 cu. ft. of air at 70 deg. weighs 0.075 lb., and the specific heat of air as you remember is 0.24, so we would have, letting Q be the volume in cu. ft. of the air:—

$$H = 0.24 \times 0.075 \times Q\ (t_1 - t_2)$$
$$\text{or } H = 0.018 \times Q\ (t_1 - t_2)$$

Applying all this to a specific problem will be helpful, so we will follow one through. Suppose your company were going to add another story to that office building across the yard. Do you remember the size of it?"

"Yes, it is 75 ft. by 40 ft. with six windows, each 4 ft. by 7 ft. and they standardize on 12 ft. ceilings," he told me.

"The walls would be of 12 in. brick, and the same kind of roof it now has, I presume, flat 1½ in. wood deck, with no insulation, and plastered ceiling. Use design temperatures of 70 deg. inside and —10 deg. outside, and figure on 5 lb. (ga.) steam pressure. The steps to be followed are:—

1. Find wall area (less windows and doors).
2. Find window area (doors are sometimes figured same as windows).
3. Find roof area.
4. Apply correct heat transmission coefficients, multiply area, coefficient and temp. diff. for each.
5. Find amount of crack to be used (½ total in this case).
6. Find volume per hour.
7. Find heat required per hour by the air.
8. Add transmission loss.
9. Find heat emission for 5 lb. steam press.
10. Find sq. ft. of radiation (EDR).
11. Determine no. and size of radiators.

"Let me see what you can do with it." So, having made a note of the steps to follow, he started on the problem. I watched him as he went along and soon he showed me his paper with the result:—

Wall area— $75 \times 12 \times 2 = 1800$
$40 \times 12 \times 2 = 960$
2760 sq. ft.
Window area— $16 \times 4 \times 7 = 448$ sq. ft.
net wall area 2312 sq. ft.
Roof area— $75 \times 40 = 3000$ sq. ft.
Heat (transmission loss)
Walls— $2312 \times 0.36 \times 80 = 66{,}586$
Windows— $448 \times 1.13 \times 80 = 40{,}499$
Roof— $3000 \times 0.26 \times 80 = 62{,}400$
169,485 B.t.u./hr.

(0.36, 1.13, 0.26 are U factors for walls, windows, roof, resp.)
(80 is temperature difference 70 to —10.)
Infiltration—
$8 \times 26 \times 39.3 = 8174$ cu.ft.
$H_1 = 0.018 \times 8174 \times 80 = 11{,}770$ B.t.u./hr.
trans. heat loss = 169,485
181,255 B.t.u./hr.
(each window has $4+4+4+7+7$ or 26 ft. of crack)
Radiators—
Emission rate is $1.109 \times 240 = 266$ B.t.u.
Radiation required $181{,}255 \div 266 = 681$ sq. ft.
Select radiators 38 in. high, 4 tubes, 4¼ sq. ft./sect.
No. sections—$681 \div 4\frac{1}{4} = 160$
Group the sections into 6 rad. with 22 sect. 132
2 rad. with 14 sect. 28
160

"Well, Chief, you certainly did that without any trouble," I told him. "For ordinary heating work, and calculations, we would not use the special emission factor, but would use 240 and 147 respectively for steam and hot water systems, however, you can see that any great variation from standard conditions might throw your results out of line so you should understand, at least, how to figure it out correctly. I want to compliment you on your work this time. It sort of makes up for some of the other times when you were not so bright."

"I must confess, G.F., I have been doing some brushing up on my own account, because as a matter of fact, they are considering putting another story on that building,—but I wanted to check myself and possibly pick up some new points,—which I did," he said with a chuckle.

Streamlining Boiler Baffles for Better Performance

Higher Efficiency and Capacity Can Be Obtained by Properly Designed Baffles. By Kingsley L. Martin, President of the Engineer Co.

NEW METHODS OF BAFFLING vertical bent tube boilers have reduced flue gas temperatures and draft losses with a resulting increase in efficiency, capacity and economy of operation. Incidentally, the installation of superheaters has been made less expensive and their effectiveness has been increased. Soot blowers can keep the heating surfaces cleaner, furnace and stoker maintenance has been reduced and outages for repair lessened. The first cost and operating expense of induced draft fans has decreased materially.

These worthwhile results have been accomplished primarily by applying to vertical boilers the cross baffle methods so widely used with horizontal water tube boilers. In horizontal boilers, the flow of the gases parallel to the tubes was abandoned generally years ago and cross flow substituted. For some reason, the application to vertical boilers of this same method, so widely and successfully used in horizontal boilers, was delayed until recent years but as its advantages have become more generally recognized, progress has been rapid.

Another equally sound and well tried horizontal boiler practice has been applied to vertical boilers with satisfactory results. Gas passages, as in Fig. 2, have been tapered so that the passes are reduced in area to conform to the reduction in volume of the gases as they cool in passing over the heating surface. By this method, the velocity and hence the heat transfer is maintained and draft loss, otherwise caused by passing through a succession of narrow openings, is avoided.

The wide open throat of the first pass insures the quick transfer of the hot gases from the furnace to intimate contact with tube surfaces. This tends to maintain a hot boiler and a cool furnace rather than a hot furnace and a cool boiler. In several cases, the furnace temperature at maximum rating has been reduced enough to bring it below the flow point of the furnace linings and to materially decrease the stoker upkeep. The comparatively slow entrance velocity of the gas into the first also tends to reduce slag accumulation on the front rows of tubes.

A marked effect on superheater design and operation has been noted. The suspended loop type is now common, with the elements located either in the space between the first and second banks of tubes

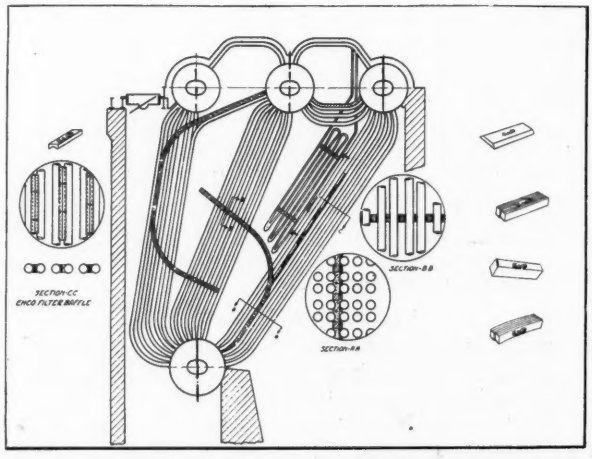


Fig. 1. Constructional details of the baffles and removable tile used by the author's company to provide openings in the baffles for the replacement of tubes

or partly in the space and partly between the tubes of the first bank or wholly in the first bank. By cross baffling the boiler, practically all the gases flow squarely across the superheater elements and every foot of their length receives substantially the same heat application. The designer knows definitely just how the gases are to pass over the elements of the superheater at all boiler ratings. As a result, one prominent designer has estimated a ten per cent better effect from the same superheater area.

Experience has shown that it is best to carry the gases in the first pass across the first and second banks of tubes and into the third bank before returning them into the second pass as shown by Fig. 2. The reason is, on reflection, obvious. The comparatively cold feedwater is generally introduced into the upper rear drum and flows downward through the tubes in the third bank. By bringing the hot first pass gases in contact with these tubes, a high rate of heat transfer is obtained. Moreover, the temperature and consequently the volume of the gases are materially reduced and less draft is required to pull the diminished volume of hot gases, which tend to rise, downward through the second pass.

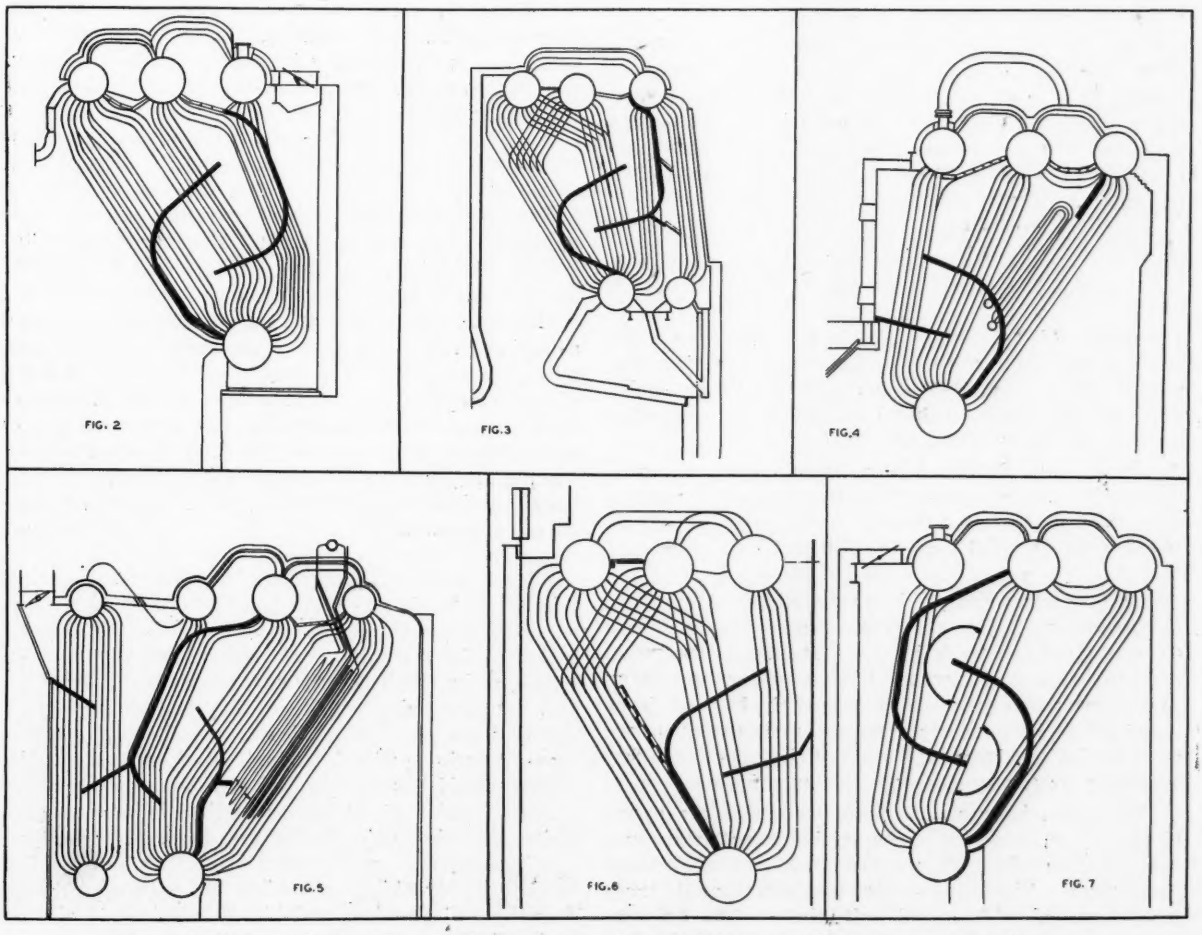
It has also been found advantageous to locate the

front longitudinal baffle on the third row of tubes in the first bank when superheater construction permits. This is as far back as the radiant heat is effective and it has been demonstrated that the gases do not penetrate to the rear of the first bank but rise vertically from the furnace to the opening of the first pass. As a result, practically all the work in the first bank is done by the first three rows of tubes as shown by the scale accumulation. Better results are therefore obtained by placing all but the first three rows of tubes back of the baffle and locating the lower cross baffle so as to flood these tubes with second pass gases as the gases make their turn into the third pass. There was, at first, considerable apprehension as to the effect of cross flow on the circulation of the water in the boiler but these fears proved to be unfounded.

A material aid in streamlining the baffles and reducing draft loss was obtained by devising methods of building curved surfaces to join the longitudinal and cross baffles. This seemingly impossible job was finally accomplished and the improvement was both immediate and considerable. The long sweeping curves eliminated eddy currents and promoted the smooth, rapid flow of the gas over the heating surfaces. Incidentally, dead gas pockets where soot, fly ash and cinders accumulate, were eliminated and this heating surface made effective. The work of the soot blowers was also made much easier.

One important feature which is growing in favor is turning the lower end of the front baffle over the mud drum, Fig. 3. By this construction, the fly ash and cinders and the unburned fines from pulverized coal and chain grate anthracite fires, are carried over back of the mud drum and dropped there by the gases as they slow down at this point, into the cinder catchers below. The U. S. Navy experience has been that an accumulation of soot and cinders left on top of the mud drum will absorb moisture from the atmosphere, if the boiler is out of service for some time. When sulphur is present, as it frequently is, the tubes and drums, are liable to suffer from rust, so cleanliness of this rather inaccessible place is highly desirable.

A design, which has been made more attractive by cross baffles, is the use of the bottom outlet through the rear wall, just above the mud drum, Fig. 4. The gases are carried clear across all three banks of tubes and, after being returned through the second pass, flow under a short lower cross baffle extending outward from the rear wall at a point just above the outlet. This design provides a convenient method of getting the gases into an air preheater or into a separate economizer, if used. The gases then rise through the preheater or economizer and pass out through the stack, saving one vertical pass and the draft loss otherwise necessary to bring the flue gases from the top outlet of the boiler to the bottom of the auxiliary unit.



Figs. 2-7. Different baffle designs which have been used successfully to meet different operating requirements

Speaking of economizers, the bent tube, two drum, integral economizer is being more frequently used and cross baffling has been successfully applied to this construction, Fig. 5. One advantage is the elimination of tube trouble sometimes experienced where hot gases pass over one side and cooler gases over the other, producing unequal expansion of the two tube banks. Here again, one vertical movement of the gas can be eliminated, with reduction in load on the induced draft fan.

In some boiler settings, the front arches are located so as to force the gases into the first bank near the cross baffle and obstruct their access to the top of the front bank. In other cases, it is desirable to insure the spread of the gases more uniformly over the entrance to the first pass. With low and medium ratings, the gases will, if the draft is kept low, rise by chimney action to the top of the furnace before entering the first bank. With high draft, the gases are pulled in immediately over the top of the baffle. The best results are, of course, obtained with automatic draft control which maintains a low, constant draft in the furnace.

Improved results have been obtained by using, in some cases, a filter baffle at the entrance of the first pass, Fig. 6. This is readily done by using loose tile in the wide alleys for the distance up from the cross baffle which is found, by operating experience, to produce the best results. The loose tile can be readily changed by the operating crew until the most effective arrangement has been discovered.

A new design, employing a well known principle, apparently has considerable merit. Power house men are familiar with the use of curved plates, known as "splitters" placed in the ninety degree bends of air ducts for the purpose of reducing the pressure required to force the air through the ducts.

This principle has now been applied to boilers and the gases are caught between the splitters, or curved metal surfaces, located in the turns, and each section of the gas stream has to keep in its own lane, Fig. 7. The piling up of the gas against the opposing baffle surfaces and their rebound into the gas stream is prevented and the draft loss should not only be materially reduced, but a better distribution of the gases over the heating surface is obtained.

The design of cross baffles for the many types of bent tube boilers, equipped as they are with various types of superheaters located in differing positions, presents quite a problem. In the usual four drum construction, the rear longitudinal baffle starts from the rear upper drum and, if the rear wall is not too close to the last bank, is placed on the back of the last tube to get all of the bank in the first pass. Otherwise, the baffle is moved into the bank as far as necessary to secure an adequate third pass, Fig. 1. The front longitudinal baffle starts from the mud drum on the back of the third row and follows the tube up as far, generally, as the superheater elements permit.

The space between the mud drum and the upper middle drum is divided into twelve equal parts and the first pass takes five, the second, four and the third pass, three. The cross baffles passing through these points are joined to the longitudinal baffles by long sweeping curves. The gas passages are then checked by calculating the heating surface passed over, the width of the openings, the velocity of the gas through the openings, the gas temperatures, making due allowance for the character of the fuel, the possible use of water walls, presence and location of superheaters and other well known factors.

In the construction, it is, of course, essential to provide for tube removal without shattering the baffle walls. Special tile, corrugated on the sides, dovetailed on the ends and curved when used in curves, are placed in the wide alleys and reinforcing bars are located in the narrow alleys where they are out of the way. A special refractory plastic material is placed, not poured, between the tile and around the rods and hardens without heat in about twenty-four hours. To remove a tube, the tile in the adjacent alley is removed and the tube taken out in the usual way. A new tube is put in and tile placed in the alley and cemented in place, making the wall as strong as when originally built.

Some interesting and unusual results have sometimes followed the use of cross baffles. In one case. a new power house was to be built on a pile foundation. By using cross baffles, the draft loss at maximum rating was reduced to such an extent that the designing engineer was able to reduce materially the height of the brick chimney with a considerable saving in foundation cost.

In another case, a very close and intensive competition for a large boiler job developed among the manufacturers. All, at first, bid on using induced draft fans, as the chimney height was limited. Finally, one manufacturer guaranteed to produce the desired capacity without the induced draft fans. As this cut both the first cost and the operating expense considerably, the contract was awarded to him. Cross baffles were carefully designed to give the minimum draft loss without sacrificing flue gas temperatures. On acceptance test, the pen went off the flow chart and indicated about twenty-five per cent excess capacity. The flue gas temperatures were lower than anticipated.

Methods of building gas tight baffles at any angle across the tubes and across interbank spaces in such a way as to permit the easy removal of tubes have been developed. The proportioning of the gas passes to the volume of the gas and the use of curved corners to streamline the baffles has made it possible for designing engineers and operating engineers to place baffles in boilers in what they find to be the most effective positions.

NEXT COMES an "alloy age" in the cement industries, or at least so predicts Dr. Edward W. Scripture, Jr., director of the Master Builders Research Laboratories at Cleveland, O. Exhaustive research indicates that certain synthetic colloids, possessing lubricating and lime-hardening properties may become as important to the cement industries as metallic alloys are in manufacturing. The introduction of a certain gelatinous colloid has been proved to reduce the necessary water 20 per cent, at the same time increasing plasticity, reducing volume changes due to temperature, making concrete more water tight, less porous, less subject to cracking, checking or crumbling under freezing and thawing, and highly resistant to all corrosive forces.

Case Studies in Power Economics

Conducted by
ZUCE KOGAN,
Kogan Industrial Service,
Chicago, Illinois

$2400 Saved in One Year by Installation of Equipment to Utilize Waste Steam at Cost of $2600

DURING the first few years of the depression there has been a general tendency among manufacturers, large and small alike, to reduce capital investments to the lowest minimum. It was the general contention that it is a lot easier to spend money for routine operation and routine expenses, no matter how high they were, than to make a given outlay of cash for equipment that in the long run would reduce these operating expenses, and plant owners went to the extent of utilizing existing equipment for such operations that they were not absolutely fitted for, so-to-speak, getting by. During the last year or so, however, there is a marked change and improvement in the thinking of plant owners and the tendency is now towards taking advantage of the possibility of reducing expenses by investing in new equipment.

In the paragraphs that follow, we wish to illustrate a typical condition. This plant was hard hit by the depression and its production began to sag rapidly in about the middle of 1930, and it did not begin to recuperate until about the end of 1933.

This plant, a malleable iron foundry, has a large air furnace for melting iron. This furnace is equipped with a 400-hp. waste heat boiler. The waste heat boiler was used to supply a 150-hp. air compressor, a 40-hp. blast fan driven by a turbine, a string of core ovens, and a boiler feed pump. During the heating season there was sufficient steam left to heat the pattern lofts and a large cafeteria building which was used exclusively by the employees. Even during the severest heating season, the waste heat boiler was generating more steam than was consumed by the various equipment and that steam was allowed to escape through the safety valves.

It so happened that with the beginning of the depression, the turbo blower broke down to such an extent that it had to be completely replaced. Having on hand a 40-hp. electric motor, and having a comparatively low rate on the purchase of electricity, it was deemed advisable not to make any investments on a turbo blower and press the motor into service. It was also found, during the same period, due to the change of the type of casting which they were making, that core drying by means of steam was not satisfactory, and having an oil tank and oil lines in the place, which they use for other purposes, they have converted the core ovens from steam heated to oil heated.

These changes naturally brought about a condition that more steam was allowed to pass out through the safety valve from the boiler. To aggravate this condition, it was finally found to be unprofitable to operate the cafeteria and it was completely closed down, hence, even during the heating season, some of the steam wasted into the atmosphere was not utilized.

In the beginning of 1934, when we made our survey, we found a condition that the only equipment utilizing the steam of the waste heat boiler were a 150-hp. air compressor and a boiler feed pump, representing a steam consumption in the neighborhood of 100 b.hp., and from 300 to 400 hp. being generated by the boiler was allowed to pass out through the safety valve into the atmosphere.

We were confronted here with a queer situation, the queerness of the situation being that an abundance of live steam at no cost is available and no place to use it. The first thought, of course, that occurred to us was the generating of power. The intermittent nature of the melting, however, necessitated either a stand-by service from the utility from which they were buying power or to install duplicate equipment and fire coal into the boiler. Calculations indicated that neither of these proposals would yield sufficient returns, because in either case it would take about five years to amortize the cost of equipment. In the first case, i.e. by purchasing stand-by power from the local utility, the cost of the stand-by service was high, and in the second case, by utilizing duplicate equipment, the investment was practically doubled, and the cost of steam that had to be generated during the shutdown of the furnace was high as the only coal available was that for melting and it was a very expensive coal. A means for using cheaper coal would have tripled the investment, hence, this method of utilizing the available steam was ruled out.

A better arrangement seemed to be the utilization of the waste steam for heating purposes. The various foundry rooms, the annealing room, shipping room and cleaning room were heated by coke in salamanders. They use a total of 400 t. of coke at $6.70 a ton, approximating a cost of $2700 per season.

We saw here immediately a means of utilizing the waste steam and thereby reduce the cost of coke to practically nothing.

They were fortunate in the fact that they had steam lines available in the various departments mentioned above. These were steam pipes that were carried through these buildings to the previous uses, and as this plant was spread over a big area, these steam pipes had to be led through these buildings.

Taking into consideration the fact that the steam pressure at the boiler was 150 lb. and that the steam lines leading from the boiler were large, which meant little drop in pressure at the farthest end, it was found that high pressure unit heaters would be the least ex-

pensive and make the greatest use of the steam available. This was recommended by us to the plant owner, who liked the idea and he asked for the specific recommendations as to the size, type and location of the unit heaters.

Upon completion of this survey, we found that about 20 unit heaters, having an average capacity of about 280,000 B.t.u. per hour, would suffice. This is based on a temperature of 0 deg. outside and a 50 deg. temperature inside. The reason we recommended only to 0 deg. temperature was because of the fact that, due to the intermittent nature of the melting of the furnace, and naturally intermittent steam supply, the coke burning salamanders would have to be retained to supply heating during these off periods. Since these salamanders were to be retained, naturally it would not pay to provide for a very low temperature, say, at —10 deg., a temperature that occurs in that locality, according to the U. S. Weather Bureau statistics, only about 1 per cent of the time, and increase the investment considerably. The same salamanders could be used to supplement the unit heaters when the heating requirements were beyond the capacity of the unit heaters.

The cost of the installation amounted approximately to $2600, the installation being made by the steam fitters of the plant.

After the first heating season it was found that the coke consumption was reduced to 40 tons, this being required in the salamanders during the time when there was no steam available and during seven days or so during which there was an average outside temperature of —20 deg. Hence, the saving during the first heating season was equivalent to the cost of 360 t. at $6.70 a ton, or about $2400. Thus, the installation paid for itself almost in one year. In the coming season, with the cost of coke rising to $7.10, the yearly saving will be proportionately higher, naturally, depending on the weather.

Dry Ice from Wells

THE FIRST lease in American history for the operation of a "dry ice" well was recently let by the U. S. Government. The well, producing almost pure carbon dioxide gas, commercially known as dry ice, is located in Carbon County, Utah. The commercial use of dry ice as a preservative for refrigeration purposes is by no means new, but hitherto it has been produced only in local plants artificially.

The well was first drilled in January, 1924, showing a gas content under terrific pressure of more than 98 per cent pure carbon dioxide. At that time there was no known means of utilizing dry ice, except locally, so that the well was plugged and temporarily abandoned. The lessee, the Farnham Dome Petroleum Co., and the operating company, the Carbon Dioxice and Chemical Co., believe that they can work out a means of shipping the carbon dioxide without great loss, either in liquid or solid form.

When the test well was first drilled, nearly 12 yr. ago, two sets of tools were lost at the gas sand level, at a depth of 3114 ft. Engineers of the prospecting company are of the opinion that, due to the sudden release of pressure, the tools were frozen solid.

The computed open flow of the well is 1,600,000 cu. ft. per day, but geologists believe that only 1,000,000 cu. ft. per day can be withdrawn, because the release of pressure at the foot of the well will cause about 600,000 cu. ft. daily to be frozen up in the sands.

Of the production, 5 per cent on the primary acreage lease, 559 acres, is reserved by the Farnham Dome Petroleum Co.; the other 95 per cent of production going to the Carbon Dioxice and Chemical Co. On the secondary acreage lease, 1,615 acres, all production goes to the latter company.

Under the lease, the primary acreage will pay a 5 per cent royalty to the Federal Government, and on the secondary acreage a sliding scale of royalty, dependent on production, ranging from 12½ to 33⅓ per cent.

Fireproofing of Structural Steel

IN AN address by S. H. Ingberg, Chief, Fire Resistance Section, National Bureau of Standards, before the American Institute of Steel Construction, the statement was made that yielding under load at elevated temperatures should be expected for structural steel. The strength of structural steel under short-time tests in tension, and in compression for relatively stable sections, is higher in the temperature range 300 to 600 deg. F. than at ordinary temperatures, the increase being as much as 25 per cent at temperatures near 450 to 500 deg. F. This, however, has no decided significance as far as fire resistance of unprotected members is concerned, since exposed in any fire of consequential import, they would attain higher temperatures in a comparatively short time. This property, however, gives in effect an added factor of safety for members that are protected so that they will not attain temperatures exceeding these limits.

The main object of structural protections is to prevent the occurrence of temperatures in the metal that induce failure under the supported loads. For recognized design working stresses, this means that average temperatures over the stressed sections of structural steel members must be maintained below about 1000 deg. F. This has been confirmed by tension and compression tests of steel specimens and also by fire tests of building members.

While much remains to be done on development of bases for estimating fire severity, judicious application of available data will enable the desired results to be attained with the use of the least bulk, weight, and cost of protecting materials. The methods of application as well as the properties of the materials are important in this respect. Thus, depending on choice of aggregates, identical columns protected with a 2-inch thickness of Portland cement concrete will develop fire resistance ranging from 1½ to 7 hr. A large range obtains also for tile and block protections, methods of application being particularly important.

OPERATION of the 33,000-v., 25,000-kw. generator at Brimsdown B. Station in England has been so satisfactory that another machine of like voltage has been ordered, thus saving the installation of main step-up transformers.

Readers' Conference

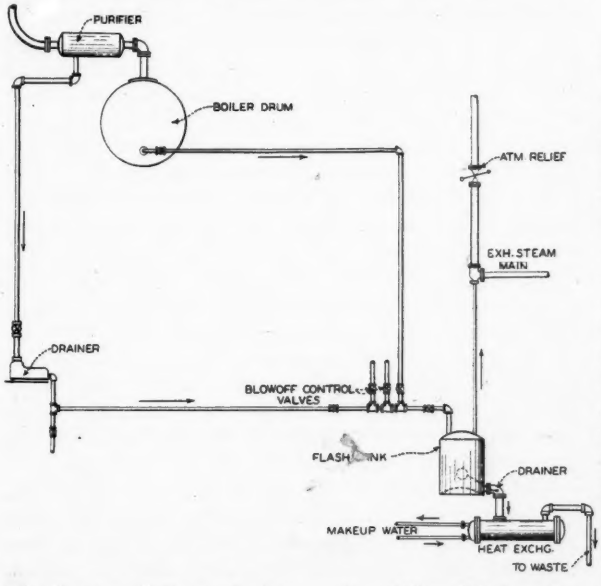
Heat Recovery from Purifier Drainer Discharge

In some industrial plants, the seasonal character of manufacturing operations necessitates operating steam generating equipment at extremely high ratings, if investment charges on equipment, which will be idle a great part of the year, are to be avoided. Even though efficiency is sacrificed and maintenance difficulties magnified, the reduction in the capital investment required will often give ample economic justification for this method of operation.

In a food manufacturing plant, where processing was carried on only during the summer months when raw material in the form of fresh vegetables was available, boiler operation at high ratings was the rule rather than the exception. Due to a favorable purchased power rate, steam production was confined to the generation of saturated steam required for process work.

As a result of a fluctuating steam demand and forcing of the boilers, considerable difficulty was experienced with carryover of boiler water into the steam lines. This contamination of the steam, in addition to causing pipe line troubles, seriously affected the quality of the manufactured product.

To eliminate the difficulties arising from steam contamination, boiler water conditions were first considered. Feedwater, containing 70 per cent of make-up raw water having a dissolved solid content of 20 gr. per gal., was supplied to the boilers. As a means of economically reducing the undesirably high concentration of mineral solids in the boiler water incidental to high rates of evaporation and the character of the feed, continuous blowoff equipment was installed.



Purifier trap discharge piped to continuous blowoff flash tank

A deficiency of exhaust steam, and a desire to reduce the high percentage of make-up water, dictated the selection of blowoff heat recovery equipment of the combination flash chamber and heat exchanger type. This equipment, while greatly reducing carryover, and effecting heat recovery from the blowoff, did not completely solve the problem of boiler water entrainment. With boiler water concentrations maintained well under 2000 p.p.m., enough carryover was present to cause processing difficulties.

Reduction of contamination in the steam to allowable limits was eventually accomplished by the installation of steam purifiers in the boiler steam leads. The discharge from the traps draining the purifiers was piped to the main boiler blowoff tank. After placing the purifiers in operation, no further processing trouble from impurities in the steam was experienced.

It was discovered, however, that the great quantity of moisture separated from the steam and discharged to waste represented an appreciable heat loss. Recovery of this waste heat was effected by diverting the purifier trap discharge to the continuous blowoff flash tank, as shown by the sketch.

Waynesboro, Va. S. H. Coleman.

Removing Dents from Copper Pipes

When copper pipes are dented internally, if in a straight length of the pipe, they can be removed by a bar mandrel driven through the pipe. The mandrel should be tapered so that the dent is removed gradually. For small dents annealing the pipe will not be necessary, but for large dents the dented surface and the immediate surrounding area should be heated externally by a suitable blow torch and then cooled as is usual for softening this metal.

When the dent is in a bend or in between bends the bar mandrel method cannot be used; in these cases water pressure must be used. The dent should first be softened, then one end of the pipe should be blanked up and then water driven into the pipe by a high pressure pump, the pipe being suitably vented so as to permit any air to escape. When the pipe is under water pressure the surface around the bend should be lightly hammered, the effect of this and the internal water pressure will be to force out the dent. When this is done the water pressure can be shut off and the pipe put back into service.

This will be satisfactory for dents with a large area but will probably be ineffective for small sharp dents. To remove these a combination of internal air pressure and heat is necessary. An air pressure of about 100 lb. per sq. in. should be applied to the pipe and the dent then heated by an acetylene torch. When at a good heat the area around the dent should be hammered lightly, the air pressure will then gradually even out the dent.

Kent, England. W. E. Warner.

Quick Reading of Gages

DEVELOPMENT in plant equipment has resulted in a large increase in the number of gages that are found in the boiler and engine rooms. It is necessary to keep an eye on all of these and the indicated readings and this may be facilitated by a simple device. On the rim of each gage paint a thin line in a contrasting color to that of the rim and corresponding to the correct working position of the pointer. If the pointer position varies under correct working conditions, paint the line wide enough to embrace both safe high and low positions.

By so doing it is possible to glance at the most complicated gage board and know conditions far more quickly than if it were necessary mentally to figure out the correct position of each.

Any variation is immediately discernable.

Passaic, N. J. MARK BELL.

Remodeling Humidifier

SOMETIME AGO it became necessary to install a humidifier unit to recondition the air in one of the rooms in our plant.

The unit is a familiar type with a motor driven fan forcing air first through a water spray, then a heating coil, and out through perforated ducts near the ceiling of the room. It is automatically controlled so that the dry bulb registers 80 deg. F., wet bulb 72 deg. F.

Although well designed and of ample capacity, trouble from the beginning was evident. There was not enough air being circulated in the room, it took a long time to change the condition of the air. One day I was cleaning the water chamber. I opened the clean out door and started the fan to dry up things. Imagine my surprise at finding a remarkable change in the air when I returned a few moments later.

The air inlet opening was 17 in. by 38 in. or 646 sq. in. In the opening before the air inlet there was a baffle plate with 817 holes, 3/16 in. in diameter. The area of a 3/16 in. circle is 0.027 sq. in. ($817 \times 0.027 = 22$ sq. in.). Showing that the incoming air was being throttled. The writer removed the baffle plate and the trouble was over.

Bayonne, N. J. THOMAS M. GRAY.

False Meter Readings

KERMIT B. HOFFMAN'S interesting letter under this title in the July number of Power Plant Engineering, page 413, reminds me of the following actual instance of false meter readings which occurred in my own "home town." This, though, was a gas meter instead of an electric meter.

A user of gas in a small New Jersey town who operated a "diner lunch" complained bitterly month after month about the high cost of gas. His bills varied from $70 to $80 per month, and, despite his sincere efforts to get along with a smaller amount of gas so that his bills might be reduced, he seldom got below $70. He couldn't stand the pressure. The gas company was told to remove the meter and take out the gas.

Loss of a $70 to $80 per month customer also looked serious to the gas plant manager. What to do? He talked it over with the treasurer of the company, a young man who, on Sundays, was minister in a local church. The young parson said, "Why not check up the meter with another meter—a meter that you know is right?"

That simple experiment was performed, and a very unusual discovery was made. It was found that the meter that had been in the diner was recording ten times the actual volume of gas that was passing through. And, of course, as a result the user had been billed ten times the amount he really should have been billed per month.

Investigation into the mechanism of the old meter revealed the fact that a ten to one ratio gear had been turned around in such a way as to make the recorder rotate ten times while it should have rotated but once.

To be sure the owner of the diner was handed a very acceptable lump sum rebate for all the months he had been using gas. And, needless to say, he is now one of the company's most satisfied customers.

Newark, N. J. W. F. SCHAPHORST.

Care of Bearings

BEARINGS WILL run hot and burn out in the best regulated factories. Sometimes there is some sort of excuse and at other times it is just plain carelessness. There are several things which may cause a bearing to run hot, but probably the most common cause is a deficiency of lubricant. To illustrate, in one manufacturing plant there were several screw conveyors used for conveying grains such as barley. These conveyors ran at a speed of about 200 r.p.m. and the bearings outside of the end ones were cast-iron hangers.

After operating for some time it was decided to inspect all of these bearings. Lubrication was provided by grease cups which were supposed to be screwed down periodically. Here is what was found. Most of the bearing had been getting grease all right but there were some which had not received any for considerable time. In one case the casting had developed a flaw and allowed the grease to squeeze out above the bearing. In several others the grease channel had become clogged and no grease could be forced through.

In order to assure more positive lubrication, the grease cups were all removed and replaced by fittings which would take a standard grease gun. This insured grease getting to the bearings as considerable pressure could be applied. A regular schedule of greasing was also established. Naturally the broken bearings were either replaced or repaired. On the next inspection every bearing was getting its quota of lubricant.

Many electric motors are now provided with roller bearings which take a special kind of grease at very long intervals. When a bearing is built so that it needs little attention for long periods it is very likely to get no attention at all. These bearings will run hot when there is too much grease or too little. As there is no way of seeing into the bearing without taking it apart it is sometimes hard to judge just what the condition is inside. Usually there is too little grease. Cases have been discovered where the grease had gradually oozed out between the plate and the frame on the inside where it was not easily recognized

as a leak. When these bearings begin to warm up, the grease gets fairly liquid and will run through a crack more rapidly than when cold, thus aggravating the trouble. In another case the bearings were all overloaded with grease because the oiler had put some grease in every week instead of every six months. This type of bearing is good but requires some attention the same as any other bearing. It is a good policy to go about and feel the bearings at regular intervals.

Oil used in motor bearings will leak through places that water will not and an oily motor is one to be watched. A slow leak is bad because the oil level goes down so slow that it is hardly noticed and if inspection is not frequent it may cause a lot of trouble. A direct break is something that can not always be avoided unless care is taken. In one case an oil gage had become broken and as a quick repair a wooden plug was inserted. The plug was forgotten and it happened that it came out just as the operator came into the motor room to shut the motor off. It is poor policy to make a repair which is not up to standard and no dependence should be put on it.

In another case a motor used in running a viner for a canning factory had been tested and inspected and oiled about a week before the season opened. One bearing burned out the first day. All the oil had leaked out, which took just about a week to drain the bearing completely. This leak was caused by a faulty plug in the oil reservoir. It is always good policy to look over the reservoir thoroughly when it is found empty after a prolonged shut down. It is also a good idea to make a second inspection just before going into operation. It is not always possible to trust in a glass oil gage either. In one case the gage glass had been plugged with a part of the washer used in making the joint so that the gage registered full when in reality there was only a little oil in the reservoir. Sometimes, not often, the bearing is poorly designed in the first place and then the only remedy is to redesign it or get a different type.

There are devices on the market to keep the oil well of a motor full at all times by means of a supplementary supply which feeds the reservoir. These devices are handy and save carrying a lot of oil around on every tour, but there is nothing which will do away with regular inspection to insure continuous everyday reliable service.

Sayerville, N. J. K. B. HUMPHREY.

Silent Chain Drive Kept in Service

INGENUITY IS SOMETIMES WORTH much in an emergency. Not long along I heard of an instance where much time was saved and a machine drive kept in service where a silent chain had broken, through the ingenuity of a millwright, until a new chain could be obtained from a considerable distance away. Faced with the proposition of getting the drive back into emergency service quickly, the millwright simply cut off reasonably sound portions of the wrecked chain, of suitable length to encircle the two sprockets upon which the chain had run, wrapped them around the sprockets and joined the ends to make them endless.

This little scheme transformed the sprockets into temporary pulleys upon which a belt could be run until the new chain arrived, and fitting a belt to the drive permitted it to be put back in service at once. It is obvious that a chain wrapped around the sprockets in this manner will give full protection to the sprockets themselves, and that they will serve relatively well as pulleys, though they might not be quite equal in roundness to a real pulley face. Even such slight departure from roundness as might be present could easily be removed by the use of a portable grinder on the "pulleys" while on the run.

Peoria, Ill. JOHN E. HYLER.

Improving Operating Accounts

POWER plant cost accounting has long been regarded by many operating engineers as an inflexible system of clerical procedure handed down from above. Like traffic rules, accounting regulations are highly impersonal matters. When the forms have been filled in, the engineer is generally glad to turn to problems of greater mechanical or electrical interest, and it is apt to leave the possibility of improving accounting methods to specialists in that field.

Some personal responsibility, however, rests upon the engineer in this matter. There is still quite a gap between accounting technique and engineering administration in many industries. In public utility power plant operation, cost accounting is greatly influenced by the requirements of state regulatory commissions, and is now fairly well standardized. Private plant accounting is less uniform. In a nutshell, the problem is to make sure that account classifications and log sheet data fit the engineering conditions in each case; for if this is not assured, the records tend to become wooden and lacking in vital significance.

An illustration may clarify the possibilities. Since the rise of interconnection between utility systems, great changes have resulted in unit costs of operation. Plant costs per kilowatt-hour have gone down under favorable base load operation, but in reserve installations, the figures have sometimes risen to fantastic heights. The accounting system sometimes appears to give inadequate consideration to the difference between what might be called reserve plant cost allocations and routine system operating charges. Thus, electrical labor in a large peak load plant may total so much per month. If this total includes the attendance necessary to maintain the equipment constantly ready for service, the labor of handling boiler, turbine and auxiliary units, the personnel expense required to operate and meter local feeders, the cost of handling switching of transmission lines and transformer banks, and of taking system readings when the plant is shut down or in partial or capacity operation, the accounting system would seem to deserve further "breakdown" of items.

It is inaccurate to charge system dispatching costs against power plant operation alone. If this is done—even under the blanket authority of state regulation—the true efficiency of plant operation becomes obscured. The engineer and the accountant may well get together and agree upon cost detailing which will present the valuable information required by the state, at the same time spotlighting the intimate phases of regular and peak load service. To make a good showing in a reserve station is hard enough anyway without being penalized for costs which do not belong directly to such an installation. The matter is too im-

portant to be set aside as a case of technical hair-splitting, for sound plant development policies hinge upon accurate cost allocations all the way from the fuel supply to the outgoing lines. In the industrial power plant field there is less danger of improper electrical allocations. Here the problem rests more frequently upon heat balance considerations, and requires the closest coöperation between accountants and engineers to insure that the records give the true cost picture.

Cambridge, Mass. H. S. KNOWLTON.

Old "B" Eliminator Chokes Make Good Bell or Signal Transformers

HAVING ON HAND a number of old "B" eliminator choke coils (mostly Philco) I set about finding a use for them. They make ideal bell ringing transformers after certain changes.

Disassemble the choke, remove the coil from the core after first determining how many layers are on the choke. This can be done easily by breaking the wire between the top layer and second layer thus creating a two winding transformer. Impress 110 v. a.c. on the main winding (total layers minus one). Read the voltage on the top layer. The ratio of 115 v. to the secondary winding voltage will tell you the number of layers, thus if the secondary voltage is 3.9 v. 115/3.9 = 29.5 layers. With a wire gage find out the wire size. Suppose it is No. 33. Its current capacity can be looked up in the tables, for No. 33 it is .05 amp.

Since most chokes have "core type" cores we use the formula:

$$A = E \times 7.50$$

where A is area of core in sq. in., E is volts per turn, frequency is 60 cycles.

In the case cited, core is .75 sq. in., then solving for E we get E = 0.75/7.50 = 0.1 v. per turn (10 turns per volt).

Since the primary is for 115 v., 115/0.1 = 1150 turns.

Count the number of turns on the top layer, in the 10 for good measure).

In the case cited 19.5 layers were removed from the choke and in their place were wound about 33 turns of No. 18 wire giving a secondary voltage of about 3 v. suitable for electric door bells.

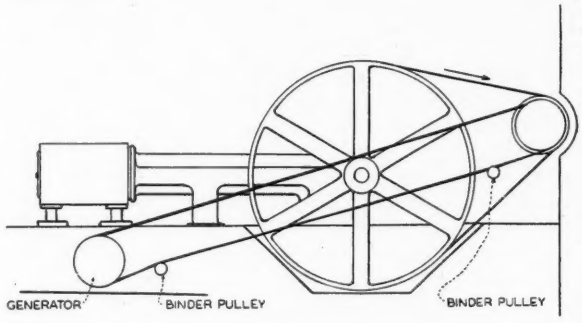
Reassemble the core, bring out flexible connecting wires, make a sheet iron box and seal up the transformer in sealing wax or patching tar used for highway work.

The above computations and data are for chokes found in the old wet type Philco "B" eliminators.

La Crosse, Wis. VERNON W. PALEN.

Elimination of Belt Vibration

THE MACHINERY in a small wood working plant was operated from a steam engine and some outside electric current. The engineer suggested that the engine was of sufficient power to pull a generator that would take the place of the purchased current. The back pillow-block was against a brick wall with just enough room for a generator pulley on the main shaft. By cutting a hole in the wall and building a foundation for the generator (as shown), the scheme worked, but the generator belt bounced up and down in a most unsatisfactory way.



By speeding the engine two turns, the harmonic frequency of the belt vibration was destroyed and the flapping of the generator belt ceased.

Lawrence, Mass. TOM THUMB.

Plant Methods of Calking

IT IS OCCASIONALLY necessary to give attention to cracks that have developed around window and door frames, skylights and other points around the plant walls, lest the entrance of cold air in winter add to the fuel bill. In general, oakum is much favored as a calking material, since it is usually necessary to keep a moderate amount of it on hand for calking plumbing joints, and it is so readily adaptable for crack calking as well. After the cracks have been tightly calked with oakum to within a quarter-inch or so of the surface, a good putty or calking compound is used to finish the job.

Some have applied calking compound with considerable success through the use of a high-pressure grease gun, substituting a tube with a suitably flattened end for the regular grease nozzle and hose. It must be admitted, however, that better results can be obtained if and when a calking tool is used that has been designed for the purpose, to be held in the hand somewhat like a spray gun and operated by compressed air. This handles the material to good advantage. Whatever method of applying the calking compound or putty may be used, it is well to give all cracks a heavy priming with lead and oil before applying the compound. This will seal the pores in brick and wood, so that the oil will not be absorbed from the compound itself. Otherwise, the oil in the putty or compound will be absorbed, leaving it lifeless, and it will soon fall from its place.

Peoria, Ill. JOHN E. HYLER.

Determining Power and Steam Costs

CAN YOU TELL me how to figure the cost of a kilowatt at the switchboard? Also, in case exhaust steam is used for heating, how much should be charged for such service or how much should be deducted from the cost of a kilowatt to determine the actual cost of power. G. E. M.

A. Your question is one which involves a great

many factors and in the absence of specific data can be answered only in a general way.

The reason for this, of course, is the fact that the power costs in any plant are dependent upon the conditions existing in that plant and these vary widely with different types and sizes of plants in different parts of the country. There is no simple or standard method or formula for figuring such costs; each case must be considered independently.

The cost of power per kilowatt hour in any plant is, of course, the total cost of operations divided by the number of kilowatt hours produced or sold—not necessarily at the switchboard but at the load. The total cost of operation involves two sets of factors; a, the fixed costs, consisting of taxes, insurance, depreciation, money use and risk insurance (profit) and b, operating costs, consisting of fuel, wages, supervision, water, oil, supplies and repairs and maintenance. It is only by taking all of these factors into account that the true costs can be accurately obtained.

In a straight condensing plant or in a straight non-condensing plant where the exhaust steam is not used for any useful or revenue returning purpose, the determination of costs is comparatively simple but where exhaust, or extraction steam is used for heating or for process work the problem becomes more complicated. If exhaust or extraction steam is used the amount that should be charged for this steam involves careful working out of the heat balance of the system and a detailed knowledge of the characteristics of the machines, and of the load.

Just to give you an idea, we will consider a very simple hypothetical illustration. Suppose that in a system such as that shown in Fig. — consisting of a boiler plant and a single steam turbine, the steam entering the turbine has a heat content of, say 1200 B.t.u. per lb., to use round numbers. Further, let it be assumed that when this plant operates on a straight condensing basis, electric power can be produced at a cost of 2 cents per kw-hr.

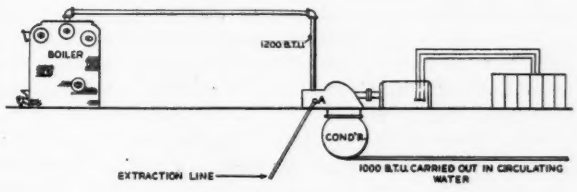
In this case, as shown by the diagram only about 200 B.t.u's out of the 1200 B.t.u. in the steam are utilized in producing electric power, neglecting the loss involved in the generator, since 1000 B.t.u's. are lost in the condenser. This loss, occurs in the heating of the circulating water.

Since a kilowatt hour is equivalent to 3415 B.t.u. and since only 200 B.t.u. out of every 1200 B.t.u. in a lb. of steam is effective in producing electric power, it will require some 17 lb. ($3415 \div 200$) per kw-hr. to produce power with this installation. Thus 1000 lb. of steam will produce $1000 \div 17$ or approximately 59 kw-hr. Since this power is sold at 2 cents per kw-hr. the steam is worth $59 \times .02$ or $1.18 per 1000 lb.

This is for the straight condensing cycle and assumes that no steam is extracted for any other purpose.

Suppose, however, that instead of sending all the steam through the turbine for the generation of mechanical power at the shaft, half of all the steam delivered to the turbine is extracted at some intermediate pressure as shown at A and assumme that the steam at this point has a heat content of 1100 B.t.u. per lb. Neglecting possible additional losses in the condenser and generator due to reduced efficiency from operating at partial load, we will get only half the total number of kilowatt hours per 1000 lb. of steam delivered to the turbine as we had before. And if this power is sold it will produce only half the former revenue.

In order to "break even," therefore, it will be necessary to charge $1.18 per thousand pounds for the extracted steam. In other words for 1000 lb. of steam sent to the turbine we will get $59 \div 2$ or 29.5 kw-hr. for which we receive 59 cents and 500 lb. of extracted steam for which we also receive 59 cents. The total revenue for the 1000 lb. of steam delivered to the turbine is still $1.18.



This is only an extremely rough consideration of the problem. It is complicated by many other factors, such as the increased fixed charges necessary because of the additional investment required by the installation of the extraction system—piping, metering, supervision. And as already pointed out, the process of extraction changes the efficiency of the turbine and the generator because of operation at reduced load, and for this reason it is necessary to investigate and analyze the load and efficiency characteristics of the machines. The steam and electrical load curves also would have to be studied because in any station the cost of power is affected by the load.

This whole question was discussed in considerable detail in two articles by Linn Helander in Power Plant Engineering some time ago.[1] The subject is also discussed at length by Alfred Lovell in his book "Generating Stations."

[1]Distribution of Energy Charges in Industrial Plants, Parts I and II, pages 450 and 522 of the October and November 1934 issues respectively.

Refrigeration Compressors and Condensers

WHAT IS THE best way to pump liquid ammonia out of the crank case of a compressor? Should one open the bypass and run the machine until the indicator reads zero or is it better to open the suction valve and pump out to another machine? M. G.

A. The best method to pump is to close the suction valve and let the machine operate until a vacuum is obtained in the crank case. This can be determined by placing a finger over the oil charging hole and slightly opening the oil charging valve. There should be no liquid in the crank case and you should check your expansion valves to find which one is open too wide as it is apparent that you are pumping a wet gas.

Q. With vertical shell and tube condenser, what is the allowable pressure difference between the condenser and the liquid receiver? M. G.

A. There should be no difference between the condenser and liquid receiver unless there is a restriction or trap in the line between the two.

Electrical Engineers *and* Students Meet *at* Purdue

PURDUE UNIVERSITY was the scene of a very interesting and well attended meeting and student branch convention of the Great Lakes District of the American Institute of Electrical Engineers on October 24-25. Several hundred engineers and students from the middle west spent an enjoyable and interesting two days discussing the latest developments in electrical engineering and in inspecting the educational and research facilities of Purdue University. The technical sessions were filled with a wide variety of papers most of which had been approved by the national technical program committee and are being published in Electrical Engineering.

The first session included papers on motor and meter design, motor starting methods and distribution problems. The second session was devoted largely to electron tube theory and practice and included papers on the characteristics of luminous tube circuits, analysis of rectifier filter circuits, and the relaxation inverter.

The third session on the morning of October 25 was perhaps the most interesting event of the meeting for this was the student technical session. At this session the selected best papers prepared by students of various universities in the Great Lakes District were presented by the students themselves. Not only were the papers at this session of most excellent technical quality and interest but what was more important was the splendid manner in which they were presented.

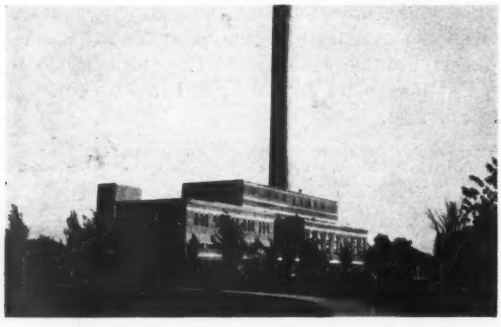


Fig. 1. The Power Plant at Purdue

Previous district meetings have awakened the older generation of engineers to the worthy competition from student members, and this session made that fact even more significant. All of the students performed well while the majority did unusually well. They spoke clearly, confidently and with remarkable poise, and all of them spoke squarely into the microphone. This is a point which many older engineers might well profit by. We don't know why it is that many of our successful engineers when before an audience delivering an address seem to possess a vast ignorance of the purpose of the microphone and the public address system. Like sheep, they constantly have to be rounded up and placed in front of it by the chairman of the meetings but even then they stray away and the audience is left to wonder about what they might be saying. To one who has attended many technical sessions at engineering meetings, the country over, it was refreshing and encouraging to observe the tenacity with which these young men held to the "mike." The younger generation, it seems, whatever their other qualifications, at least will be microphone conscious. It is significant that this student session was one of the main sessions—it was not a parallel session.

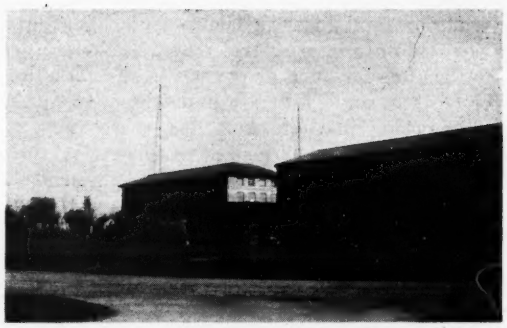


Fig. 2. The Electrical and Mechanical Engineering Buildings

Purdue University for many years has specialized in extra high potential research, including the design, construction and calibration of the surge generator, its accompanying cathode ray oscillographs and later the specialized development of the sealed-off cathode ray oscilloscope with double image possibilities and its application to television. These developments were discussed in a series of papers on the afternoon of October 25 and demonstrations of the cathode ray oscilloscope and television given by Professor R. H. George and his associates.

It is impossible here to present even a resumé of the papers but all of them reflect an intense interest in the many developments in progress in the whole electrical field.

The practice of holding technical society meetings at universities is one to be highly recommended and the A.I.E.E.'s progressiveness and foresight in this direction are to be commended. Last spring a national convention was held at Cornell and now this district meeting was held at Purdue.

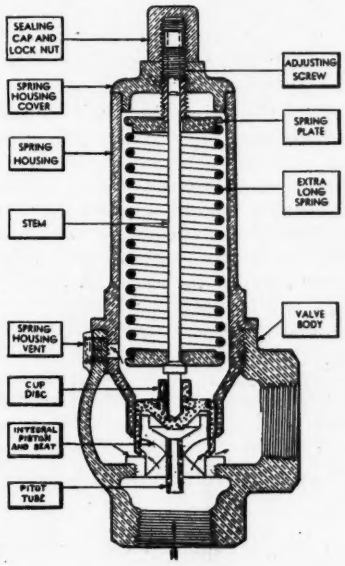
In opening the meeting, Dr. A. A. Potter, dean of the schools of engineering at Purdue, commented upon this very desirable evidence of coöperation between the engineering societies and the educational institutions, both as it affected the universities and the students and also the engineers and the societies. The engineering students in the universities today, said Dean Potter, represent the membership of the engineering societies of tomorrow and from this closer coöperation between the universities and the societies will result better universities and better engineers.

Dean Potter spoke briefly upon the educational facilities at Purdue, and mentioned particularly the Public Service Engineering Course which is open to a limited number of selected students. The purpose of this course is to train and fit young men for positions in public life. This course provides engineering rather than law as a background as has heretofore been the case. Students for this course are carefully selected as to their moral character, family and early environment. Out of nearly a thousand engineering freshmen, Dean Potter said, probably only 30 or 40 would be permitted to enter this course.

New Equipment

New Klipfel Valve

KLIPFEL MFG. CO., 2641 W. Harrison St., Chicago, recently announced a new relief valve of radical design known as the Klipfel cup disc relief valve. This valve has large capacity with very close regulation and a flow characteristic, of pressure against capacity, which is almost flat. This change in the char-

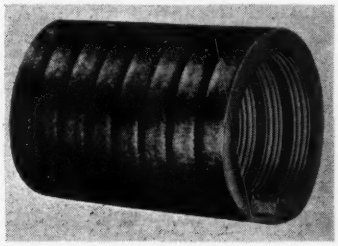


acteristic from the conventional valve is obtained from the combination of the new cup shaped valve disc and a pitot tube facing up stream. Pressure from this pitot orifice acting on the upper side of the valve, is responsible for the flexibility of the characteristic to meet different conditions. Changes may be made by varying the design of the pitot tube. Tests on a 1 in. valve show a regulation accuracy from 96 to 98 per cent for a capacity range from 0 to 88 g.p.m. The valve incorporates five features said to be responsible for the performance, a cup shaped valve disc, the pitot tube, an extra long spring, an outside sleeve surrounding the cup valve and a narrow edge on the valve.

John Crane Semi-Metallic Packing

CRANE PACKING CO., 1802 Cuyler Avenue, Chicago, Ill., has developed a new type packing consisting of a resilient backing of long fiber asbestos cloth with an inserted, heat resisting, expansion rubber back. A grooved and perforated metallic wearing face is fixed to the backing which provides the maximum antifrictional operation. The packing is thoroughly impregnated with special "John Crane" graphited lubricant which flows freely through the open grooves and perforations to the surface of the rod on which it is used.

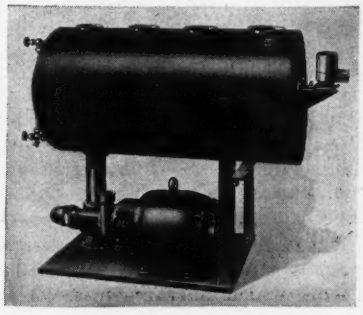
This new packing is marketed under the trade name "John Crane" Style 380 "Metal Face" and is a flexible, compressible, self-lubricating type packing especially



recommended for use on steam rods of engines and pumps and on air and gas compressors. It performs exceptionally well on new or overhauled equipment at temperatures up to 450 deg. F.

Condensate Return Units

ONE OF THE LATEST developments by the Worthington P. & M. Corp., Harrison, N. J., is a complete series of 54 sizes and types of automatic Monobloc condensate return units applicable to a wide variety of condensate return services such as steam heating systems and steam process plants. Ratings range from 2,000 to 40,000 sq. ft. of direct radiation or equivalent. Condensate flows by gravity into the storage tank, trips a float switch at a predetermined depth and the motor is automatically started. When the tank is drawn down to a predetermined minimum level, the motor is automatically stopped. Pump capacities for the 54 sizes range from 3 to 60 g.p.m.; storage tank capacities from 22 to 98 gal. and discharge pressures from 10 to 40 lb. per sq. in.



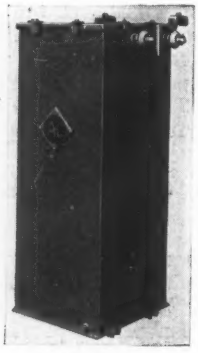
Steam Jacketed Rotary Pumps

HEAVY DUTY rotary pumps are now produced by Worthington Pump & Mach. Corp., Harrison, N. J., for pumping practically all kinds of thin, thick, viscous, hot, cold, or corrosive liquids not easily handled by other types of pumps, including those that solidify when cool, such as asphaltum, rosin, lard, soap, etc. Complete lines of standard and steam-jacketed pumps of this type are made to handle pressures up to 300 lb. per sq. in., temperatures up to 650 deg. F., with capacities of from 10 to 2500 g.p.m. For viscous and solidifying liquids the pumps are steam-jacketed. For high temperatures the stuffing boxes are water-jacketed. Internal sleeve and internal roller bearings are used for non-corrosive liquids; external ball bearings for corrosive liquids. The pumps give straightway, continuous, non-churning and non-foaming discharge. No valves. No gaskets. No trappings of liquid. No pulsations. All parts easily accessible. The single extra deep stuffing box on the internal bearing type pump is subject to suction pressure only. These pumps operate quietly, readily handle considerable vapor, air or gas suspended in the liquid, and require practically no attention. Practically any drive arrangement is applicable.

Branch Feeder Regulator

ALLIS-CHALMERS announces a low cost regulator, designated Type BFR, covering a 10 per cent range in 8-1¼ per cent steps. The new unit is responsive to voltage conditions and employs for its vital parts tried and proven elements of the more elaborate station type AFR regulator. Flexibility in application is provided so the unit can operate between 10 per cent boost and 0 per cent boost; 7½ per cent boost and 2½ per cent

buck; 5 per cent boost and 5 per cent buck; 2½ per cent boost and 7½ per cent buck; 0 per cent boost and 10 per cent buck. This BFR unit is available for not only 2400 v. applications but for 6900, 7620, 11,500, and 13,200 v., both single and three phase.

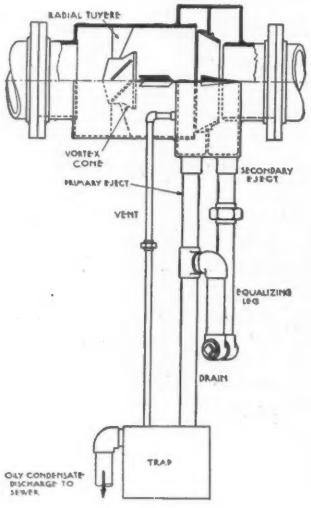


Standard sizes: 25 to 200 amp., 2400 v., single-phase or three-phase. 10 to 100 amp., 6900 v., single-phase or three-phase. 10 to 100 amp., 7620 v., single-phase. 5 to 50 amp., 11,500 and 13,200 v., three-phase.

Oil Purifier for Exhaust Steam

To REMOVE oil from exhaust steam, Centrifix Corp., Cleveland, Ohio, announces Type RV Exhaust Line Purifier. Referring to the accompanying illustration, there are two distinct separating stages, the first recovering the bulk of the entrainment while the second acting as a refining stage, to give the same degree of performance with low or high per cent of entrainment.

On entering the purifier body, the steam passes through the tuyere, a number of radial blades inclined at a 45-deg. angle, to cause a vigorous whirling motion, which throws the entrainment outward and carries it forward spirally along the inner surface of the sleeve until the primary discharging slot is reached, when entrainment is driven into the outer concentric pocket by centrifugal force. At the secondary slot the operation is repeated.



In such a whirling mass there is always a low pressure area at the center which draws entrainment and seriously interferes with separation; the effect of the vortex is prevented by the vortex cone.

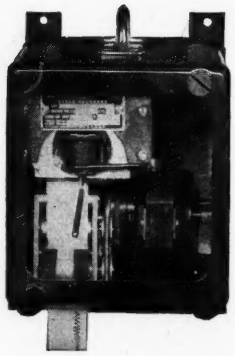
Casing is faced and drilled to the 125-lb. American standard; tuyere blades are stainless steel, welded to the casing and to the central cone member. Drains, one from each stage, are connected to a common trap with an equalizer leg to balance any pressure difference, the vent providing a path of escape for steam in the trap or drain pipe, thus materially increasing the capacity of the drain system.

A New Cycle Recorder

A NEW CYCLE recorder, a device for giving pictorial evidence of the length of time current flows in an alternating-current circuit, is available from the General Electric Company. This cycle recorder is designed for use with resistance welder timers—in calibrating or adjusting these timers or as a means of producing a permanent record of a weld time. By indicating when an accurate re-setting of welding time is attained, the new device is very useful in duplicating welds previously found to be satisfactory. The instrument therefore not only records optimum welding time for a specific job as determined by experiment, but enables the production welding machines to be easily and quickly set to reproduce this time.

The new device records, on a strip of paper, the cycles of duration of current flow. It is oscillographic in nature but no attempt is made in its design to make it follow wave form accurately. It consists of a compact unit, 5½ by 7½ by 7½ in. containing a frequency-responsive element, marking mechanism, paper-tape drive, and paper-tape supply.

The frequency-responsive element is a polarized reed driven by a coil which surrounds it. This



driving coil is tapped for use at either one or five amperes, although a 110-v. coil can be obtained if desired. The reed vibrates and follows the alternations of the current.

The recording device is inkless and simple. A stylus carried by the vibrating reed presses very lightly on a moving strip of very thin paper under which rotates a graphite roll. The paper is so thin that the record can be read from either side of the strip. A 2000-ft. roll—one loading for the cycle recorder—is only 5 in. in diameter. The paper is, nevertheless, tough and permanent. Both paper and graphite roller are readily renewed.

A small a.c. motor drives both the graphite roll and the recording tape.

The entire device is so simply and sturdily built that it is well suited for field use. Very little skill is required to apply and operate it.

COMBINATION of vegetable gums and heat-treated oils as a base to form a film designed to be air and water tight yet give a hard elastic coating that will not peel nor crack, to protect surfaces against corrosion and decay is announced by Technical Coatings, Inc., 9-15 Park Place, New York City. The new film is applicable to wood, metals, dry concrete and dry plaster. As primers metallic zinc is recommended for black or galvanized surfaces and for salt water exposure. For fresh water exposure and humid conditions, combination of zinc and aluminum is preferred. For average conditions a balanced red lead is suitable. Finish coats in standard colors are available. Application is by brush, spray or dipping, thinning by pure turpentine. Drying time is 4 to 16 hr. depending on conditions.

Non-Clogging Centrifugals

OPEN IMPELLER, non-clogging centrifugal pumps for handling solid materials in suspension, gritty liquids, liquids containing stringy material, etc., are now being made in a wide range of sizes by the Worthington Pump & Mach. Corp., Harrison, N. J. The pumps are of

rigid monobloc construction, convenient, dependable and low in first cost. They are compact, the greatest overall length of the largest size being only 23 in.

Ratings range from 10 to 250 g.p.m. against heads of 10 to 100 ft.; ½ hp. to 7½ hp.; 1500 r.p.m. to 3600 r.p.m.; a.c. or d.c.; 50 and 60-cycle; single-phase or polyphase. In addition, where standard construction does not suit, special constructions and characteristics are available.

High-Pressure Pump for Hot Water

GREAT ECONOMY of fuel obtainable with high-pressure steam has brought it into use in most central stations and many industrial plants, but percentage of power for driving the boiler pump is increased and, with regenerative heating, the pump must handle high pressure and water at high temperature. This involves problems in axial balance, prevention of leakage through the casing and running joints and along the shaft, also in avoidance of distortion.

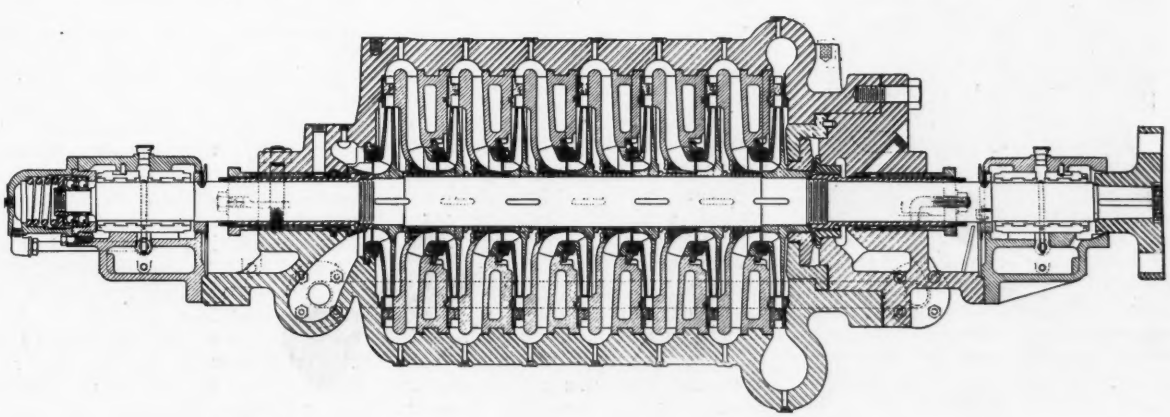
In a boiler feed pump designed by De Laval Steam Turbine Co., of Trenton, N. J., for pressures up to 1600 lb. and temperatures to 300 deg. F., special means is used to maintain axial balance. Design of the impellers is such that the end thrust is due in slight amount to the reaction of the entering liquid a slight thrust due to reduction of pressure on the back of the impeller because the liquid between impeller and casing wall tends to revolve with the impeller, but mainly to the pressure generated by the impeller multiplied by the annular area between the wearing ring joint and the shaft. This net thrust is balanced by a leakage joint past a balancing member back of the last impeller, leakage being bled off to the suction. In the De Laval pump, instead of direct bleed to suction, there is a secondary restriction, the leak-off joint is radial, with a radial clearance between rotor and casing through which water has to pass, the clearance being regulated by the axial position of the impeller, movement of the rotor to the left restricting the inflow of water and to the right increasing it. As the area of the balancing disk is greater than the suction area enclosed by the impeller wearing rings, the rotor is kept in balance without reducing balancing chamber pressure quite to suction pressure, leaving a margin for adjustment. The rotor will move axially until pressure in the balancing chamber is such as to hold the rotor in equilibrium.

In starting the pump up dry, this hydraulic balancing action is inoperative, hence a spring-loaded ball thrust bearing is mounted on the outboard end of the shaft, axial clearance being sufficient to avoid metallic contact when the ball thrust bearing is up against the shoulder in its housing. When the pump is operating, the balancing disk acts so that the ball bearing is forced away from the shoulder and is subject only to the force of the spring.

The stationary ring which opposes the balancing disk is clamped tightly against the casing by a solid end cover bolted to the end of the casing to prevent leakage through the joint, and the soft packing of each stuffing box is protected by labyrinth packings and a leak-off. Leakage from discharge to suction past the individual impellers is opposed by double labyrinth rings, one screwed to the impeller, the other held in a recess in the interstage diaphragm. This permits large running clearances without excessive leakage, which is advantageous when dealing with high pressures and temperatures.

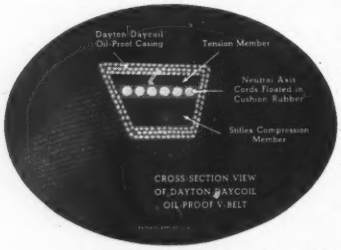
In one combination, the boiler feed and booster pumps are mounted on a single shaft, driven either by a motor or a steam turbine. The two-stage booster pump takes water from the condensate pump at 2 lb. and discharges at 125 lb. through the feedwater heaters to the main boiler feed pump which is designed for 647 g.p.m. at suction pressure of 105 lb., discharge of 880 lb. and with water at 275 deg. F. As has been done in emergency, the turbine can be operated exhausting to atmosphere for a long period.

IN BUILDING a rectangular tank 50 by 6 by 6 ft. and an accumulator tank 18 ft. by 2 ft. 6 in. diam. for a rice treating plant at Birmingham, Ala., the treating chamber of ⅜-in. plate reinforced by angle iron and the accumulator of 17/64-in. plate were welded by Fleetweld. Welding was done by Chicago Bridge & Iron Works with equipment supplied by Lincoln Electric Co. of Cleveland, Ohio.



Oil-proof V-belt

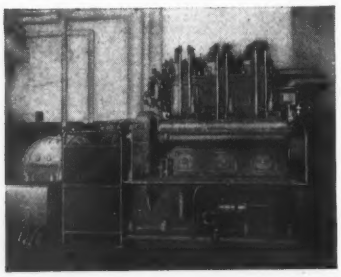
Marketed under the name "Daycoil" the first completely oil-proof V-belt developed for general industrial use has been announced by The Dayton Rubber Mfg. Co., Dayton, Ohio. Its principal field of application will be in locations where only conditions are found in normal operation. This belt carries


Dayton Daycoil Oil-Proof Casing
Tension Member
Neutral Axis Cords Floated in Cushion Rubber
Stiflex Compression Member
CROSS-SECTION VIEW OF DAYTON DAYCOIL OIL-PROOF V-BELT

the same laminated construction principles as the regular Dayton cog-belts for general transmission applications, plus the specially designed casing of the new synthetic compound to resist oil. Dayco, the oil-proof material used in the construction, has all the properties of natural rubber, such as flexibility, plasticity and resiliency, plus aging properties many times that of rubber and much greater abrasive and wearing qualities when subjected to oils and solvents.

New Diesels

BUILT IN SIZES ranging from 100 to 800 hp., in from 2 to 8 cylinders, the new Type RHB Diesel engine of the Chicago Pneumatic Tool Co., New York, N. Y., are of the four cycle, direct injection type and are convertible to gas engines with a few minor changes. The Bosch system of direct injection is used and the engine is pressure lubricated. The box type base is built with a large lubricating oil reservoir, frames are of the semi-en-bloc

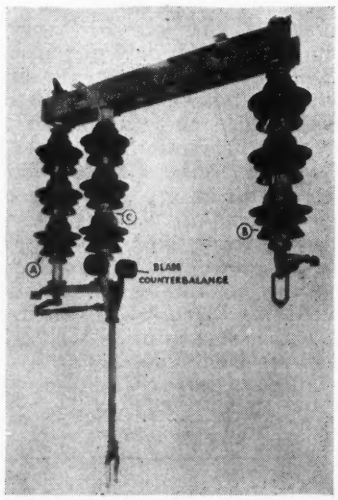


type and the cylinder liners are made of a special nickel cast-iron. Inlet and exhaust valves are interchangeable and carried in cages to afford quick removal for inspection and reconditioning. The exhaust valve cage is water cooled. The trunk type piston has six compression rings and two vented oil control rings, one above and one in the piston skirt to remove excess lubrication. The governor is driven direct from the camshaft driving gear and is fitted with a hand adjustment for varying the speed over wide range with close regulation. Special synchronizing regulators for engines operating in parallel can be supplied if desired.

High Voltage Balanced-Blade Switches

THE "FMR-239" motor or manual operated type developed by the Delta-Star Electric Company, Chicago, Illinois, assembled for inverted mounting is of the balanced-blade type so adjusted that even should any link of the operating mechanism fail, the blade will not fall open or fly closed.

There are two rotating insulator stacks per pole: (A) at the blade hinged end, (B) at the contact end. Stack (A) operates a crank arm connected to the hinged blade on the stationary stack (C), the blade being lowered or raised from this point. The rotating stack (B) operates the main H-shaped contact.



In the opening operation, rotating stack (B) at the contact end first turns to entirely release the H-shaped contact from the blade's forked contact. Rotating stack (A) at the hinge end then turns, lowering the blade to full open position. In closing, the reverse operations take place.

The main blade contact is of the pressure line-type with large areas for heat dissipation and insuring proper contact pressure with cool operating characteristics. The forked blade main contact-shoe is a hard drawn copper fitting withing a floating polished stainless steel spring which with its copper contact-shoe is supported by a bronze casting clamped to the blade.

Westinghouse Orders 21 Per Cent Higher

OPERATIONS OF THE Westinghouse Electric & Manufacturing Company for the third quarter of 1935 compared with the third quarter of 1934 were as follows:

	Quarter Ended Sept. 30, 1935	Quarter Ended Sept. 30, 1934
Orders Received	$30,497,620	$25,213,271
Sales Billed	29,723,546	23,963,896
Net Profit	2,557,452	*332,062

*Net Loss.

Orders received during the 1935 quarter were 21 per cent higher than for the same quarter in 1934. Sales billed were 24 per cent higher.

Comparative figures for the two nine-month periods were as follows:

	Nine Months Ended Sept. 30, 1935	Nine Months Ended Sept. 30, 1934
Orders Received	$95,482,535	$79,105,881
Sales Billed	92,019,563	69,245,486
Net Profit	8,822,640	*363,787

*Net Loss.

Orders received during the nine-month period were 20.7 per cent higher than in 1934; and billings were 32.9 per cent higher.

Fourth International Heating and Ventilating Exposition

EXTENSIVE PLANS are being made in advance of the opening of the Fourth International Heating and Ventilating Exposition to be held in the International Amphitheatre, Chicago, during the week of January 27 to 31, 1936. Previous expositions have been held in Philadelphia, Cleveland and New York. Its exhibits this year will cover a number of fields which, while large in themselves, are all interested in the problem of human health through proper air conditioning. Among the equipment to be exhibited are: furnaces, boilers, unit heaters, control heating systems, hot water heaters, air conditioners with accessories, refrigerators, insulating material, fans, blowers, air filtering equipment and application of such equipment to many industries.

The conduct of the exposition and all details are in charge of the International Exposition Co., Grand Central Palace, New York. N. Y.

News From the Field

ANNOUNCEMENT has been made by Crane Co., Chicago, that H. H. Simmons on November 15 became advertising manager of the company. In this position he will coöperate with other departments of the company having to do with sales. Mr. Simmons comes to Crane Co. after a nine-year association with Russell T. Gray, Inc., Chicago advertising agency, of which he has been vice president and account executive. Mr. Simmons was graduated from the University of Ill. in civil engineering and has made an intensive study of markets in the fields of power plants, oil and gas, railroads, chemicals, foods, municipal and construction.

THE KENNEDY VALVE MANUFACTURING Co. of Elmira, New York, announces the appointment of Frank De Witt & Co., 5736 Twelfth Street, Detroit, as its representative in the lower peninsula in the state of Michigan including the city of Detroit.

J. L. BUSEY, who assumed the presidency of the General Electric Supply Corporation on November 1, is now responsible for one of the largest distributing organizations in the world. With 23 main houses, 11 local houses, and 63 branches, it furnishes distributing channels for numerous lines of G-E products, including apparatus, construction materials, and electric appliances for both industry and the home.

LINK-BELT Co. has moved its executive offices from 910 S. Michigan Avenue, Chicago, to the Bell Building, 307 N. Michigan Ave., where they will occupy the entire twenty-third floor, and the north half of the twenty-first floor.

HARRY T. PORTER, 2436 Reading Road, Cincinnati, Ohio, has been appointed representative for Cincinnati and vicinity by the American District Steam Co., North Tonawanda, N. Y.

THE LINCOLN ELECTRIC Co., Cleveland, Ohio, announces opening of new offices and representatives as follows: Peoria, Ill., 923 So. Washington St., in charge of W. I. Miske, a graduate of Univ. of Va. and recently in the Chicago office; Memphis, Tenn., in charge of O. B. Farrel, graduated from Ala. Poly. Inst., then salesman for Farrel Cheek Fdy. Co., the Hoover Co., and Lincoln Electric Co.; Lew Hinchman, former Ohio State Univ. football star and honor student, will be in Chicago offices, 1455 W. 37th St.; Paul W. Corp, graduate of Univ. of Wisc., will be located in Milwaukee under George M. Johnson, district manager; E. H. Weil, a graduate of Miami Univ. and of Univ. of Cincinnati, then with Allis-Chalmers will be added to the sales personnel at San Francisco.

ANNOUNCEMENT is made of the appointment of Edmund Burke as manager of industrial sales for Crane Co., Chicago, effective November 1, to further develop the industrial and construction markets for the use of valves, fittings and specialties. Prior to 1910, when Mr. Burke entered the service of Crane Co., a good part of his engineering experience was in the construction and operation of mechanical, electric and hydraulic plants. As sales engineer for Crane Co. he specialized in work among engineering and industrial organizations, until 1913 when he was made manager of sales of specialities. Since 1921 he has been in charge of sales to the oil and gas industries, until his recent appointment.

W. Howard Pape, who succeeds Mr. Burke as manager of sales to the oil and gas industries, has been associated with this industry since 1914 in the capacity of designing, operating and sales engineer. He joined the Crane organization in 1927 as special representative in the New York and, later, the Boston territories. During the last 6 yr. he has been in charge of oil sales work in the Mid Continent and Gulf Coast areas.

ANNOUNCEMENT has been made by the Combustion Engineering Co., Inc., New York, that Otto de Lorenzi has been appointed Assistant General Sales Manager. Except for two years in the American Expeditionary Forces Mr. de Lorenzi has been with the company since 1916 in various engineering capacities.

THWING-ALBERT INSTRUMENT Co. is announced by Dr. Charles B. Thwing, president, as the new name adopted by the Thwing Instrument Co., Philadelphia, Pa. This change in name involves no change in ownership, management, policy or product. Edward J. Albert whose name is now included in that of the company has been associated with the concern for the past 17 yr. as manager and secretary of the company.

HENRY W. FOULDS has been elected vice-president of The Permutit Co. and will direct all sales promotion and advertising. Mr. Foulds, a graduate chemical engineer, brings to his new position 20 yr. of experience in selling. Assisting Mr. Foulds will be L. S. Ferguson, manager of industrial sales; O. P. Harris, manager of domestic sales, and H. H. Wilkinson, advertising manager.

REPUBLIC STEEL CORPORATION announces the appointment of George E. Clifford as District Sales Manager in the Los Angeles, Calif., District. Mr. Clifford was appointed following the resignation of George F. Emanuels who has been in charge of the Los Angeles Office for several years. Mr. Clifford joined Republic Steel Corporation in 1930, as Assistant Manager of Sales in the Pipe Division.

WILLIAM FREDERICK DURAND was awarded, at the annual meeting of the John Fritz Medal Board of Award, the gold medal for 1936 for notable achievement "as authority in hydrodynamic and aerodynamic science, and in its practical application; outstanding leader in research and in engineering education." This award was made unanimously by a Board having for its members sixteen past-presidents of the four American societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers. Doctor Durand is Professor Emeritus of Mechanical Engineering, of Stanford University, California.

COMBUSTION ENGINEERING Co., INC., New York, announces the appointment of Wilson Machinery & Supply Co., Inc., Lexington, Ky., and William Franklin, Buffalo, New York, as representatives of its Industrial Stoker Division for the sale of C-E stoker units of small size. Also Industrial Combustion Co., Philadelphia, has been appointed as representative in the territory comprising southeastern Pennsylvania, southern New Jersey and Wilmington, Delaware, for this line of stokers.

ANNOUNCEMENT is made of the organization of the Columbia Pipe & Supply Co., which will maintain complete warehouse and pipe shop facilities to serve the trade at wholesale at 3610 S. Morgan St., Chicago. The officers of the company are: Thomas Floro, president; H. E. Shoff, vice president; J. T. Arenberg, treasurer, and C. W. Zoeller, secretary.

For the Engineer's Library

THE I. T. E. CIRCUIT Breaker Co., Philadelphia, has recently issued three bulletins on protection of electric circuits. One of these, Bulletin 935 is devoted to protection of circuits in steel mills. The second, Bulletin 1035, is devoted to the general discussion of protection and the third, Bulletin No. 1134, discusses the protection of direct current generators.

A GUIDE TO APPLICANTS FOR DIRECT LOANS is the title of a pamphlet prepared by the Committee on Direct Loans of the National Conference of Business Paper Editors and The Associated Business Papers, Inc. This is the second study on direct loans and supplements the report What About Direct Loans to Industry? which was released recently. A Guide to Applicants for Direct Loans differentiates briefly and concisely between the three sources of governmental aid; Reconstruction Finance Corporation, Federal Reserve banks and Federal Housing Administration. Outlining the legal requirements which must be met in securing such aid—the study indicates to what uses borrowed funds may be put, what costs as to interest rates borrowers must pay, how to route applications to secure the speediest action, what equipment purchases are eligible for loans, and many other questions of vital interest to prospective borrowers. In addition, the guide includes case studies of applications which were rejected by Federal Reserve banks, pointing out weak spots in financial and managerial set-ups. Copies are available at 25c per copy at A. B. P. headquarters, 330 West 42nd Street, N. Y. C.

NEW quick detachable connector for cable is announced by The Lincoln Electric Co., Cleveland, Ohio, in a new bulletin on Arc Welding Supplies.

FIRE TAMERS, a story of research and development of refractory cement, is the title of a 12-p. booklet issued by Johns-Manville, 22 E. 40th St., New York City, showing laboratory scenes and the "mighty midget," so-called because a little of it accomplishes so much.

AMENDED RULES I and II and General Rules and Regulations of the Bureau of Navigation and Steamboat Inspection of the U. S. Department of Commerce is available and may be obtained from the Government Printing Office in Washington. This is a 183 page, paper bound pamphlet, covering specifications for material used in boilers and appurtenances and the design, construction, installation, inspection and repair of boilers and piping systems by this department. A number of changes are incorporated, dealing among other things with welding and fusible plugs.

PRESSURE REGULATORS for the Gas Industry is the title of catalog 32A recently issued by the Fisher Governor Co. This is a 74 page, 8½ by 11 booklet containing a complete and detailed description of the various pressure control equipment made by that company and includes charts and tables showing the capacities and characteristics of various types of valves.

CLASSIFICATION AND SELECTION OF ILLINOIS COALS is the title of Bulletin No. 62 published by the State Geological Survey Division of the Department of Registration and Education of the State of Illinois at Urbana, Ill. The bulletin was prepared by Gilbert H. Cady and in addition to other information on testing, specifications and standardization of laboratory procedure, it contains complete proximate and ultimate analysis of various types of coals from all sections of the state.

AN EIGHT PAGE bulletin has recently been issued by the Lawrence Pump & Engine Co. of Lawrence, Mass., describing their new Electropump, a compact, low cost, centrifugal pump unit for small and moderate capacities, ranging from 10 to 360 g.p.m. at heads of from 10 to 360 ft. The bulletin includes a complete description with several pages devoted to tables giving heads and capacities of the various sized units.

QUIMBY ROTEX PUMPS is the title of bulletin R-200 issued by Quimby Pump Co., 340 Thomas St., Newark, N. J. These pumps were developed for service in the specialized equipment field for handling viscous liquids and semi-liquids, such as oils, sludges, molasses, pastes, soaps and similar products. The bulletin describes the pump and gives the standard specifications.

NATIONAL UNIT HEATERS made by National Radiator Corpn., Johnstown, Pa., are described and illustrated in a recent bulletin 30T11 issued by the corporation.

THE METAL CLEANING HANDBOOK of the Magnus Chemical Co., 150 South Ave., Garwood, N. J., gives in 200 pages the various ways of cleaning metal by the Magnus system, equipment required, details of solutions used and the cleaning operations and discusses the differences for different metals.

THE ROTO CO., 140 Sussex Ave., Newark, N. J., has just issued a pamphlet describing the new and improved Roto Junior air driven cleaners for small tubes such as used in marine boilers, condensers and heat exchange units. Features just added to this cleaner are a new scraper head with inexpensive replacement blades, a universal joint for attaching the cleaning heads to the motor and a quick-acting air valve directly behind the motor for the convenience of the operator and one man operation.

ENGINEERS HANDBOOK, a practical manual giving recommended types, specifications and design of piston rings for machine designers and operators has been published by the American Hammered Piston Ring Co., of Baltimore, Md. The third edition of this book numbers 152 pages, 5½ by 7½ in. in size, and it is bound in flexible cloth.

COMBUSTION ENGINEERING CO., INC., New York, has just issued an attractive 8-page bulletin, which describes and illustrates in detail its "Design MRO" multiple-retort stoker. Test data and typical operating results are included.

PENNSYLVANIA PUMP AND COMPRESSOR Co., Easton, Pa., has recently issued bulletins Nos. 166 and 224, the former describing the company's Class 7-AT and 8-AT roller bearing type vacuum pumps, and the latter describing Class SMD, SHD and SLD sleeve bearing pumps. The bulletins are well illustrated with halftone cuts showing various features of these pumps.

UNDER THE TITLE, "Outstanding Performance with Simplicity," The Brown Instrument Co. of Philadelphia, Pa., has issued a catalog commemorating its 75th anniversary, and offering to industry a complete line of air operated controllers. Another catalog by the company, designated as No. 8900, deals especially with instruments for controlling temperature, pressure, flow and liquid level. This is an attractive bulletin giving complete descriptions with many detailed photographs which bring out the special features of the instruments described.

THE PATTERSON-KELLEY CO., East Stroudsburg, Pa., has just published its catalog section No. 801, dealing with the Patterson fuel oil heaters, giving a description of the equipment, dimensions and capacities for the various sizes.

REPUBLIC STEEL CORP. is distributing a folder under the title The Greatest Pipe Show on Earth which lists and describes the various types of tubular products manufactured by the company and its subsidiaries.

IN THE NEW brochure-catalog, FM-4A, of J-M Industrial Friction Materials of both flexible and rigid styles, been published by Johns-Manville, are brief descriptions of the complete line of industrial friction materials, including the woven and compressed and the folded and compressed products of the flexible types and the friction block and moulded varieties of the rigid styles. Materials for facing both cone and disc clutches are also described. Included are two condensed tables giving the comparative characteristics of J-M industrial friction linings and brake blocks and of friction facings, and to simplify the selection of the most suitable friction material for specific conditions, are three tables of recommendations, covering brakes and clutches. Copies may be obtained by writing to Johns-Manville, Executive Offices, 22 East 40th Street, New York City.

CONSTRUCTION, OPERATION and the practical application of Ruths accumulators, the thermal flywheel, to a number of industrial conditions are covered in a new bulletin, R.A.-35-5, recently released by Foster Wheeler Corp., 165 Broadway, New York City.

DETAILS OF CONSTRUCTION and application, and capacities of the new Yarway impulse type steam trap are covered in a recent circular, T 1720 issued by Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

CARBONDALE BRINE COOLERS is the title of an 8-page bulletin, No. 1103, containing photographs, drawings and technical information, recently published by the Carbondale Machine Corp., Harrison, New Jersey. Horizontal, vertical, single-pass and multipass brine coolers ranging from small sizes to the largest brine coolers made are treated, and design, construction and uses of the several types of Carbondale units are briefly considered.

SUN OIL CO., Philadelphia, Pa., has issued a handbook on Coal Mining Equipment Lubrication which gives the company's recommendations covering the lubrication of all types of mining equipment including such power equipment as steam engines, steam turbines, electric generators, air compressors, Diesel engines and conveying equipment.

DEAERATING FEEDWATER HEATERS of various types manufactured by the Worthington Pump & Machinery Corp., Harrison, N. J., are illustrated in a four page bulletin, W-210-B17.

INSTRUCTIONS for the handling and operation of tube fabricating equipment are contained in Bulletin No. 40 recently published by Parker Appliance Co., Cleveland, O. The bulletin also contains descriptions of Parker fittings and tools.

METALLIC and semi-metallic gaskets, sheet and stuffing box packings, sealing compounds, gasket cutting tools, valve discs, filter screens and metal stampings are treated in Catalog 48 recently issued by Goetze Gasket & Packing Co., Inc., New Brunswick, N. J. This 64-page booklet describes many new gasket types, is well illustrated with half tones and blue print diagrams, and contains size and price data.

FRICK CO., Waynesboro, Pa., have recently issued a two page sheet, Bulletin No. 226 A, giving the specifications and dimensions of 5 sizes of Frick enclosed type compressors developed primarily for Freon refrigeration.

COMBUSTION 1935. This is a report of Combustion Subcommittee of the Prime Movers Committee of the Edison Electric Institute and is issued as publication No. C-6. Price to non-members of the Institute is $2 and copies may be obtained direct from the Edison Electric Institute, 420 Lexington Ave., New York City.

As in past years, the report is made up of the operating experiences of various companies, this year's report being divided into sections dealing with oil and gas fuels, combustion control, furnaces, stokers, ash and dust elimination, mechanical draft equipment, pulverizers and pulverized fuel. Each section includes statements by operation companies and by manufacturers.

AIR CONDITIONING 1935. This is a report of the Air Conditioning Subcommittee of the Sales Committee of the Edison Electric Institute, containing factual data on air conditioning installations. It is issued as publication C-7. The price is $1.25 to non-members and may be obtained from the headquarters of the Institute at 420 Lexington Ave., New York City. It is made up largely of installation and operating data for various installations throughout the United States and covers office buildings, residences, specialty shops, banks, restaurants and stores. A number of effective advertisements used by power companies throughout the country are reproduced.

OIL AND GAS ENGINES, 1934-1935, is available as publication No. C8, of the Edison Electric Institute, 420 Lexington Ave., New York. The price to non-members in the U. S. A. is $1.25. This is a report of the Oil and Gas Engine Subcommittee of the Prime Movers Committee and gives a summary of Diesel engine progress and trends, examples of recent installations, notes regarding the classification of Diesel oils and a separate section on high speed Diesel engines. Other sections of the report deal with operating and maintenance, specifications. cost data and operating records of 65 engine units.

PROPERTIES OF AMMONIA SOLUTIONS, presented in table and chart form, with an explanation of their use, is available in pamphlet form and may be obtained from the American Society of Refrigerating Engineers, 37 W. 39th St., New York, N. Y., for 15 cents. These tables and charts were prepared by A. B. Stickney primarily for use in absorption refrigeration cycles.

WACO DATA BOOK for Lamp Purchasers answers important questions commonly asked about lamp quality, lamp efficiency, burning life, imported lamps, guarantees, tests, voltage, etc., and illustrates the complete line of Waco electric light bulbs manufactured by the Wabash Appliance Corp. of Brooklyn. Copies available for distribution by the manufacturer.

GRATON & KNIGHT CO., Worcester, Mass., has issued a handbook on leather belting and power transmission which is full of technical data, charts and curves which are of particular value to men in charge of belting and power transmission equipment.

THE NEW YORK BLOWER CO., Chicago, Ill., has recently issued a number of bulletins dealing with Comet air stream unit heaters and Type ME fans. These bulletins are well illustrated to aid in giving the reader a conception of the construction, installation and use of this equipment.

THE LAWRENCE MACHINE & PUMP CORP., 371 Market Street, Lawrence, Mass., has issued Bulletin 208 dealing with pumps designed especially for general dredging service, for pumping sand and gravel, pumping of ashes and cinders, and for other applications where the pump is required to handle mixtures of water and abrasive solids.

UNDER THE TITLE, A Fine Tool Deserves a Perfect Drive, Allis-Chalmers Mfg. Co., Milwaukee, Wis., has released a new buletin, No. 1259, on Texrope Drives for machine tools. The bulletin shows numerous typical installations of this V-belt drive to modern machine tools of all kinds.

AS A REMINDER to the trade of its 25 yr. of engineering, designing and manufacturing of superheaters, economizers and air preheaters, the Superheater Co., 60 E. 42nd St., New York City, is distributing an appropriate folder reciting some of the more important accomplishments of the company during that long period of excellent service to the field.

NEW PSYCHROMETRIC CHART for air-conditioning computations is announced by General Electric Co., Air Conditioning Dept., Bloomfield, N. J. It has been developed by research and experiment to simplify the reading of values so that values of all characteristics can be read from any point on the chart without the use of auxiliary curves, thus giving great accuracy and saving time. It is designed for permanent use at desk or drawing board, is 14 by 20½ in., printed in light brown and black on sheets sealed to both sides of a thin plate similar to bakelite and with surfaces coated with a resinous compound so that pencil lines of any color can be readily drawn and erased. This new chart is obtainable at nominal cost from the office at Bloomfield or through General Electric air-conditioning dealers throughout the country.

FORM NO. 1870 is a new circular issued by Diehl Mfg. Co., Elizabethport, N. J., covering the new line of Diehl Gear Motors which includes helical gear and worm gear units, either direct connected or coupled types, in single, double and triple reductions for horizontal, vertical and right angle drive.

NORTON COMPANY, Worcester, Mass., has recently issued an 8-page bulletin describing their refractory bricks, alundum and crystalon.

IDEAL COMMUTATOR DRESSER CO., Sycamore, Ill., has just issued a new 64-page catalog-data book which lists not only the entire Ideal line, but also much information on the care and upkeep of commutators, slip rings, etc.

ALLIS-CHALMERS BULLETIN 1153-A is a new publication on their engine type alternators for use with any kind of reciprocating prime mover. They are available for standard engine speeds from 100 r.p.m. to 600 r.p.m. in standard ratings from 25 to 10,000 kv-a.

IN NICKEL STEEL TOPICS for October, issued by the International Nickel Co., Inc., 67 Wall St., New York City, are described uses of nickel steel alloys ranging from the 300-mi.-per-hr. Bluebird automobile and castings for Bonneville Dam to Philadelphia jewelers who bought stainless steel for white gold. Applications are described for oil well pump rods, coal mining equipment, machine tools, boilers and other pressure vessels, caterpillar tractors, automobiles and streamlined trains.

APPLICATIONS of the Iron Fireman stoker to National Radiator Corp. boilers are illustrated and described in leaflets recently issued by Iron Fireman Mfg. Co., Cleveland, Ohio.

Planes Rush 1½ Tons Motor Repair Parts 3000 Miles

PREVIOUS AIR EXPRESS RECORDS were shattered by a shipment of approximately 3000 pounds of stator coils and other parts recently rushed from Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., to California for repair of a 900 hp., wound rotor hoist motor on which plant operation of the Diamond Match Company was wholly dependent. The shipment was made in two sections, a day apart, being carried in special Stinson tri-motor planes to Cleveland and then transferred to planes of the United Airlines at Cleveland for the hop to California. The first shipment was received in California about 72 hr. after the request for "service with a rush" was received. Normal service on such an order would probably have required 11 days —a week to fill, to get the equipment ready at East Pittsburgh and four or five days shipping time.

The damaged hoist motor was received in Westinghouse's Emeryville, California Works on Thursday night and repair parts ordered from East Pittsburgh by wire Friday morning. The customer was insured for continuity of its plant operation so renewal parts were rushed through so that half the equipment was ready Sunday for delivery to the Railway Express Agency. Airplanes did the rest. The first batch of coils arrived at the Oakland, California airport early Monday and the rest on the evening plane. The Express Company met each plane with a special truck and had the shipment in Westinghouse's Works 30 min. after each plane's arrival.

After the stator and rotor of the motor were rewound and the broken bracket repaired by welding and remachining, the motor left the Emeryville shop at 4:30 p.m., Friday arriving at the Diamond Match Company at 6:30 a.m., the next morning and was put in service that afternoon hoisting logs.

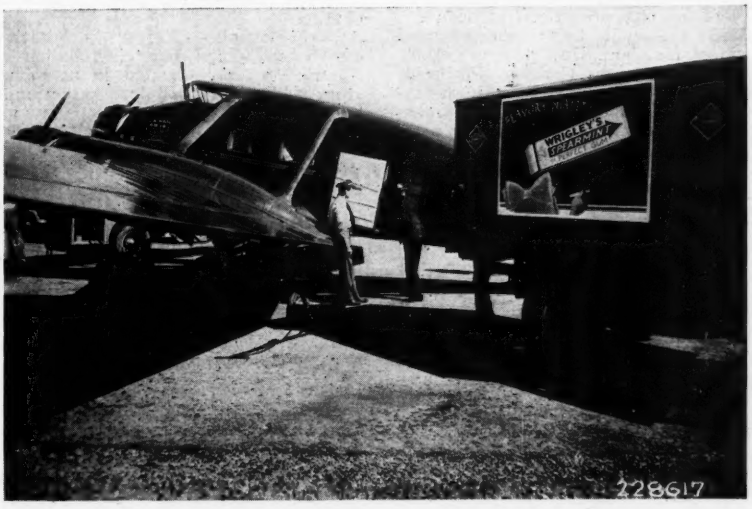
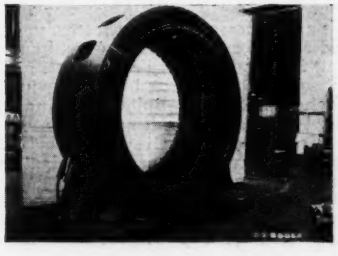


Fig. 1—Loading part of the 2700 pound shipment of motor parts which were rushed by air from Westinghouse's East Pittsburgh Works to California for repair of 900 HP hoist motor. Express charges were $2,007.

Fig. 2—Good as new and ready to haul logs again. Stator and rotor were rewound by coils rushed 3000 miles by airplane.



Power Plant Construction News

Calif., Los Angeles—General Motors Corporation, General Motors Building, Detroit, Mich., plans installation of electric power equipment in new multi-unit assembling plant for Buick, Pontiac and Oldsmobile automobiles at South Gate, near Los Angeles, where large tract of land is being acquired. Cost over $2,000,000.

Calif., Santa Monica—Douglas Aircraft Co., 3000 Ocean Park Boulevard, plans installation of electric power equipment in new one-story addition to plant, 200x300 ft. Cost over $150,000. Edward C. Taylor and Ellis W. Taylor, 803 West Third Street, Los Angeles, are architect and engineer, respectively.

Iowa, Ogden—Common Council is considering construction of a municipal electric light and power plant, and electrical distributing system. Cost about $91,000. Financing will be arranged through Federal aid. J. M. Pilmer, 810 Prospect Road, Des Moines, Iowa, is consulting engineer.

La., Lake Providence—Lake Providence Ice Co. has authorized plans for rebuilding of ice-manufacturing plant recently destroyed by fire, loss including two oil-engine units, two ice-making machines and auxiliary equipment, totaling close to $50,000.

Me., Portland—City Manager, 389 Congress Street, has plans maturing for new steam power house, coal pocket with distribution facilities, and mechanical laundry at City Hospital. Cost about $90,000, with equipment. E. L. and E. S. Higgins, Congress Street, are architects.

Mich., Detroit — Koppitz-Melchers, Inc., 2169 East Atwater Street, brewer, plans steam power house, including boiler and engine departments, in connection with new multi-unit brewery on 2½-acre tract of land at Dubois Street and Detroit River, for which superstructure will soon begin. Electric power equipment will be installed for brewery service. Entire project will cost close to $1,000,000. Mildner & Eisen, Hammond Building, are architects.

Minn., Hopkins—Village Council has preliminary plans for new municipal electric light and power plant, using Diesel engine generating units. Surveys and estimates of cost are being made by Power Engineering Co., Metropolitan Life Building, Minneapolis, Minn., consulting engineer.

Minn., Minneapolis—Minneapolis-Honeywell Regulator Co., 2727 Fourth Avenue, South, manufacturer of heat regulators and other control instruments, plans installation of electric power equipment in new six-story addition. Cost about $200,000. E. J. Prondzinski, Pence Building, Minneapolis, is architect.

Minn., Rochester—Public Utility Board, City Hall, A. J. Lentfer, secretary, is considering extensions and improvements in municipal electric power plant, including installation of new boiler unit and accessories, superheater, underfeed stoker, coal pulverizing equipment, draft fans and auxiliary equipment. Early call for bids is expected. Burlingame & Hitchcock, Sexton Building, Minneapolis, Minn., are consulting engineers,

Mo., Anderson—City Council has plans under way for new municipal hydroelectric generating plant, including electrical distribution system. Transmission line will be built from station to city limits. Cost about $100,000. Albert C. Moore, Joplin, Mo., is consulting engineer.

Mo., Marshall—Common Council will soon take bids for extensions and improvements in municipal electric light and power plant, including installation of new equipment for increased capacity. Cost about $150,000. Bond issue has been authorized in conjunction with Federal financing. Henrici-Lowry Engineering Co., West Tenth Street Building, Kansas City, Mo., is consulting engineer.

Mo., St. Louis — Laclede Power & Light Co., 1017 Olive Street, has plans under way for new steam-electric generating plant, reported to cost over $2,000,000, and for extensions and improvements in power substations, transmission lines and distributing system, to cost approximately $500,000. Work will be carried out in 1936. Company engineering department is in charge.

Neb., Blair—Common Council plans early call for bids for new municipal electric light and power plant, using Diesel engine generating unit. Cost about $60,000. Financing has been arranged. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

N. Y., New York—Board of Directors, New York University, Washington Square, plans new power plant in connection with three-story engineering building and laboratory to be erected at University Avenue and 180th Street. Mechanical engineering and hydraulic laboratories will be installed in building. Entire project will cost about $400,000 and financing in that amount has been arranged through RFC. Collins P. Bliss is dean of College of Engineering at institution.

N. C., Charlotte—Duke Power Co., plans extensions in transmission and distributing lines in Piedmont area for rural electrification, including power substation and service facilities, totaling over 300 miles. Proposed to carry out program in 1936. Cost over $150,000. Company engineering department is in charge.

N. C., Charlotte—Old Dominion Box Co., 22 Ninth Street, Lynchburg, Va., plans installation of electric power equipment in new paper box and container plant at Charlotte, where former textile mill of Savona Mill Co. has been acquired and will be remodeled and equipped for plant. Cost close to $50,000.

N. C., Raleigh—Carolina Power & Light Co., plans rural electrification program comprising over 100 miles of transmission and distributing lines, with power substation and service facilities. Cost reported over $75,000.

Ohio, Barberton—Columbia Alkali Corporation, Barberton, plans installation of electric power equipment in new plant addition, to be used for production of chlorine, a new line of output for company. Cost over $1,000,000, with machinery. Company is a subsidiary of Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa.

Ohio, Cincinnati—Red Top Brewing Co., 1747 Central Avenue, plans new steam power house for service at plant, installation to include two boiler units with accessories, stokers and other equipment. Bids scheduled to be asked soon. Carl J. Kiefer, Schmidt Building, is consulting engineer.

Ont., Toronto—Ontario Hydro-Electric Power Commission plans hydroelectric power development on Ogoki and Nipigon Rivers in Northern part of Province, with station installations to total about 218,000 hp. capacity. Project will include power substations, switching stations and transmission lines. Cost about $3,000,000. Project is being submitted to Provincial Government for approval.

Pa., Titusville — Cyclops Steel Co., Titusville, plans installation of electric power equipment in new addition to tool steel works. Former factory of Romeson Mfg. Co., on adjoining site, idle for number of years, has been purchased and will be remodeled and equipped for expansion. Cost about $75,000. C. T. Evans is president.

S. D., Watertown—North American Creameries, Inc., 122 North Broadway, plans new one-story power plant for dairy products factory service, using Diesel engine-generator units. Proposed to proceed with project at early date.

Tenn., Lewisburg—Common Council plans construction of municipal power substation and electrical distributing lines. Power will be secured from system of Tennessee Valley Authority. Cost about $100,000. Bond issue has been authorized in conjunction with financing through Federal aid. Proposed to begin work in near future.

Va., Danville—Department of Public Utilities, E. C. Brantley, manager, is having plans prepared by Charles T. Main, Inc., 201 Devonshire Street, Boston, Mass., consulting engineer, for proposed municipal electric light and power plant on site about 60 miles from city, and proposes early call for bids. A transmission line will be constructed to city limits, where large power substation will be built. Fund of $2,750,000 has been secured through Federal aid.

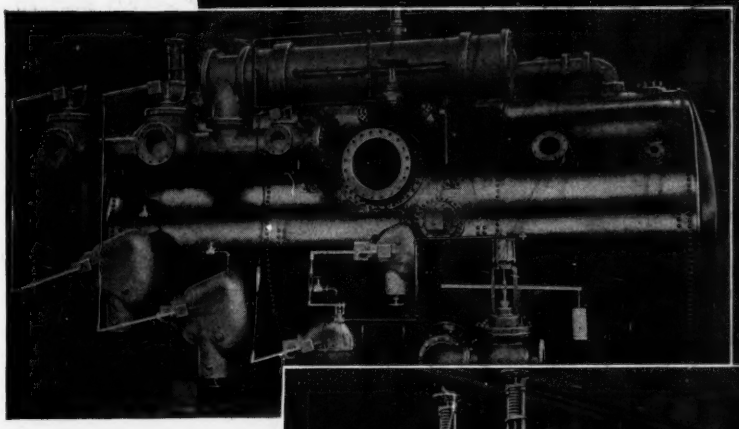
Va., Hopewell — Allied Chemical & Dye Corporation, 61 Broadway, New York, N. Y., plans installation of electric power equipment in new multi-unit chlorine manufacturing plant at Hopewell, on which work will begin at early date, to be operated by Solvay Process Co., 40 Rector Street, New York, an affiliated interest. Cost about $1,000,000. Company engineering department is in charge.

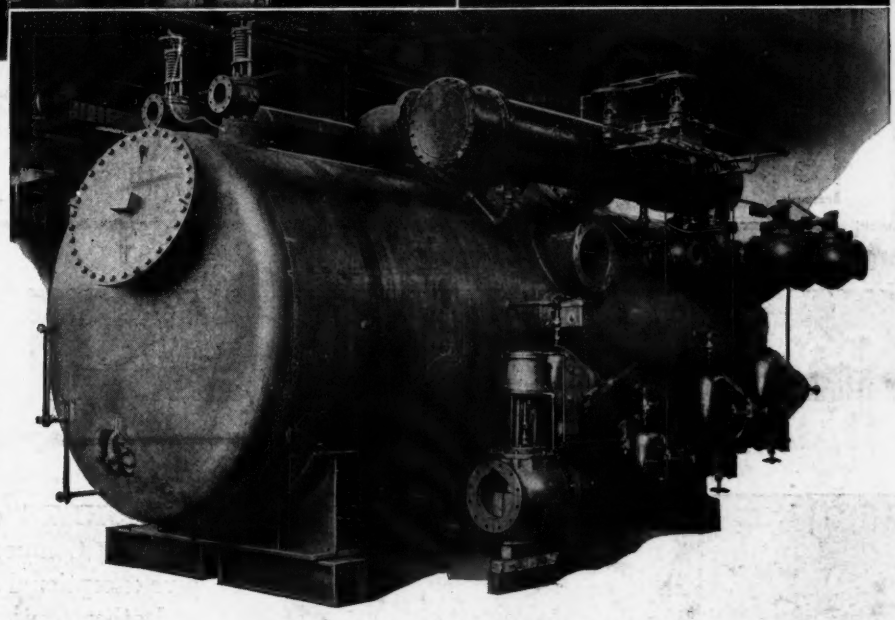
Va., Roanoke—Viscose Corporation of Virginia, Inc., plans installation of electric power equipment in new one-story addition to cellulose rayon mill, 80x100 ft., to be used as a caustic soda reclaiming unit. Cost about $100,000. Work scheduled to begin at once. Company is affiliated with Viscose Co. of America, Inc., Marcus Hook, Pa.

W. Va., Clarksburg—Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., plans installation of power equipment in new addition to branch sheet glass plant at Clarksburg, to be used for batch-house and auxiliary service, replacing existing old unit. Cost about $150,000. Company engineering department is in charge.

Wis., Beloit — Electrical Equipment Mfg. Co., 1326 Clary Street, plans one-story power house in connection with new one-story factory, 150x200 ft., on Collie Road. Entire project will cost over $60,000.. W. R. Cones is general manager.

One of the nation's big plants gets its second big ELLIOTT DEAERATING HEATER





Showing developments in up-to-date design and construction

These two similar, steel-plate Elliott deaerating heaters were built for one of the largest and most highly publicized industrial power plants in the country. The riveted unit (capacity 1,000,000 lbs. per hour) was built in 1930. The welded unit (capacity 1,280,000 lbs. per hour) was built this year.

The purchase of the second unit tells the tale of "Characteristically Elliott" performance of the first.

Both units are furnishing oxygen-free feed water to 1400-lb. pressure boilers. They take heating and deaerating steam from turbine extraction. Control and accessory equipment is provided to allow full automatic operation with steam pressures varying from above to below atmospheric. The deaerating heaters, of course, deliver water heated right up to the saturated steam temperature.

The contrast in construction of the two units is interesting. During the past five years, welding has replaced riveting when steel plate construction is indicated.

Elliott deaerating heaters are always carefully designed for the service intended, and are built to your requirements in every detail.

ELLIOTT COMPANY

PITTSBURGH, PA.

Deaerator and Heater Dept., JEANNETTE, PA.

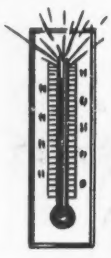
District Offices in Principal Cities

N-932a

GARLOCK 7021

COMPRESSED ASBESTOS GASKET SHEET

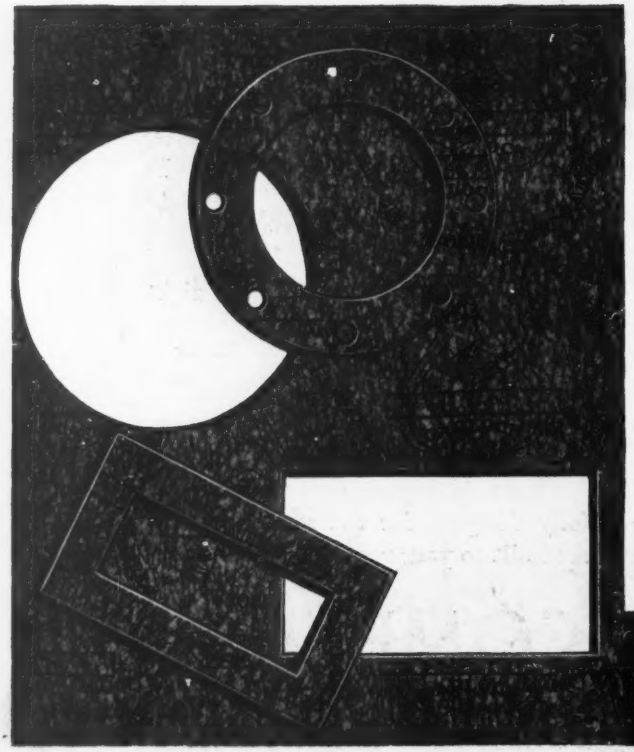
for



HIGH TEMPERATURES

EXTREME PRESSURES

GASOLINE | **OIL** | **GAS** | **STEAM**



GASKETS cut from GARLOCK 7021 Compressed Asbestos Sheet give exceptional service on pipe lines and other equipment handling gasoline, oil, gas or steam at high temperatures and extreme pressures. Tough, yet resilient—GARLOCK 7021 is particularly economical and efficient for severe conditions.

THE GARLOCK PACKING COMPANY
Palmyra, New York

In Canada:
The Garlock Packing Co. of Canada, Limited, Montreal, Que.

GARLOCK

You Know the Armstrong Record for Low Maintenance Cost

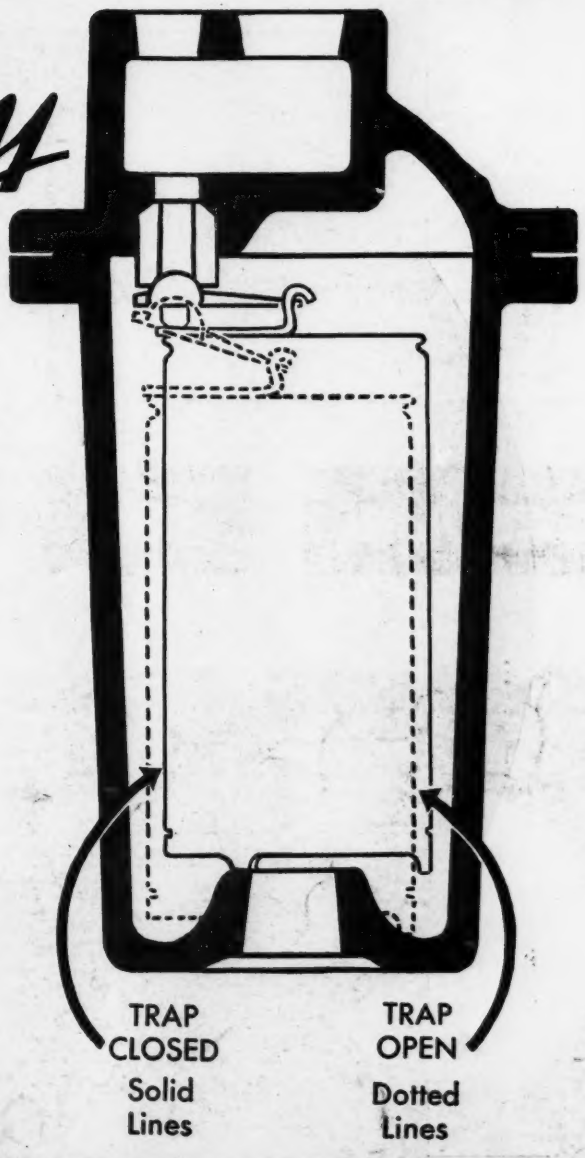
Here's Why

WHEN you see an Armstrong trap demonstrated or study the design, you recognize instantly that the simplicity of its operating mechanism is a fundamental reason for dependability and low maintenance cost. As pictured here, there are only two moving parts in an Armstrong trap, the *inverted bucket* and the *free-floating valve lever.*

The standard bucket is brass and, for service where even greater resistance to corrosion is needed, stainless steel buckets can be furnished. There is no wear on the open bucket; it merely moves up and down in a body of water actuating the valve lever through a frictionless connection.

The lever has been so designed as to eliminate the common ills of lever mechanisms such as wear on pinions and getting out of adjustment. The Armstrong lever has a knife-edge fulcrum and, after the momentary pull on this edge to "crack" the valve, the lever literally floats.

Of course, low maintenance cost also depends on quality—typified by the heat-treated chrome steel valves and seats—and on proper selection and application of traps for hard service which is facilitated by accurate capacity ratings and by the cooperation of our representatives. But in addition to these factors, the simplicity of operation, shown above, is obviously a vital reason for the amazing record of trouble-free service which Armstrong traps have built up for a generation.



ARMSTRONG

MACHINE WORKS, Three Rivers, Mich.

B&W TYPE B PULVE

In Service . . .

These pulverizers of 12,600 pounds capacity were installed for a mid-western utility and are but two of a total exceeding 212 B&W Type B Pulverizers now in service, delivering from one-quarter ton to fifty tons of coal per hour.

VERIZERS *are* RELIABLE

These records of individual pulverizers indicate that the availability of B &W Type B Pulverizers is greater than the requirements of the boilers they serve.

46 DAYS CONTINUOUS OPERATION

. . . day and night, twenty-four hours per day, in a central station.

100% AVAILABILITY FOR 2 YEARS

. . . in large industrial plant. Operation about eighty-five per cent of the time.

79 DAYS UNINTERRUPTED SERVICE

. . . twenty-four hours per day in a cement plant.

STILL GOING AFTER 51 DAYS

. . . previous availability, one hundred per cent for one hundred and eighty-six days.

AVAILABILITY 100% FOR 2 YEARS

. . . no shut-downs for repairs . . . in fact, no repairs and even little wear.

2 1/3 YEARS . . . 100% AVAILABLE

. . . in a central station, and operated approximately seventy-five per cent of the time.

And . . . *dependable service* is but one of their several characteristics that result in lower steam costs. Write for details of these modern pulverizers . . . address The Babcock & Wilcox Company . . . 85 Liberty Street . . . New York . . . N. Y.

Consistent Fineness

Low Maintenance Costs

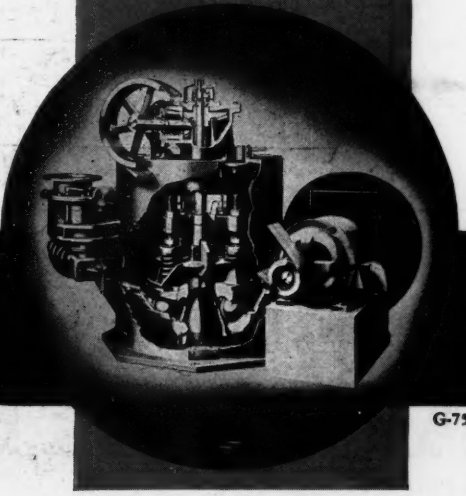
Low Power Costs

Uniform Flow of Coal to Burners . . . Safe Starting

For Pressure and Suction Systems

Will Handle Wet Coal

Adapted to Automatic Boiler Control



G-75-T

BABCOCK & WILCOX

EARLY RETURNS...

PLANT	1 HAVE THESE WALLS GIVEN COMPLETE SATISFACTION	2 WHAT IS YOUR MAINTENANCE ON WATER WALLS?	3 HAS THERE BEEN ANY REFRACTORY MAINTENANCE ABOVE THE WATER WALLS?	4 DO YOU BELIEVE THAT THE WATER WALLS HAVE INCREASED THE STEAMING CAPACITY OF THE BOILER UNIT AND REDUCED THE MAINTENANCE ON THE STOKER?	5 WHAT IS THE AVERAGE RATING AND LENGTH OF SERVICE SINCE THE WALLS WERE ORIGINALLY INSTALLED ?
1	YES	NONE	NO	YES	210% 2 YEARS
2	YES	NONE	RELINED ONCE IN 6 YEARS	YES	225 — 250% CONTINUOUSLY FOR 7 YEARS
3		ONLY 2 TUBES IN 5 YEARS	NONE		100 — 200% RATING FOR 5 YEARS
4	YES	NEGLIGIBLE	NO	YES	175 — 200% FOR 4 YEARS
5	"COMPLETE SATISFACTION"	25 CAST BLOCKS ON 3 FURNACES IN 5 YEARS	NO REFRACTORY IN PERFECT CONDITION DESPITE BTU RELEASE RATES OF 55,000 AVERAGE AND 24 HOUR PEAKS OF 75,000	COULD NOT CARRY LOAD WITHOUT WATER WALLS	325% AVERAGE 450% FOR LONG PEAK PERIODS
6	"COMPLETE SATISFACTION"	VERY LOW--NOT OVER $500 A YEAR FOR 5 YEARS	NO	YES COOLS FURNACE, DECREASES MAINTENANCE AND INCREASES AVAILABILITY	200 — 225% CONTINUOUSLY FROM THE FALL OF 1928
7	"COMPLETE SATISFACTION"	NO FIGURES CONVENIENT	WALLS LAST FOR 6 YEARS	YES INCREASES AVAILABILITY AND DECREASES MAINTENANCE	200% FOR 4 WEEKS AT A TIME
8	YES	RECENTLY MADE FIRST REPAIRS: 4 TUBES 10 C. I. FACE-PLATES 3 BLOW-OFF NIPPLES	NO REFRACTORY ABOVE WALLS	YES	200% SINCE INSTALLED
9	"PERFECTLY SATISFACTORY"	NONE EXCEPT GASKETS AFTER EACH YEAR'S CLEANING	NO REFRACTORY ABOVE WALLS	INCREASED CAPACITY 50% ON INDIANA SCREENINGS OF A LOW FUSING ASH TEMPERATURE	225% OR 50% OVER RATING WHEN NO WALLS WERE USED
10	"COMPLETE SATISFACTION"	"PRACTICALLY NOTHING"	"PRACTICALLY NOTHING"	YES	200% CONTINUOUSLY SINCE 1929
11	YES	NONE	NO	YES	150% AVERAGE CONTINUOUSLY SINCE INSTALLATION, JANUARY 16, 1934
12	"DONE ALL WE EXPECTED OF THEM"	"NOT SUFFICIENTLY IMPORTANT TO WARRANT SEGREGATION"	"RELATIVELY LOW"	INCREASED MAXIMUM OUTPUT WITH SATISFACTORY AVAILABILITY	UNITS HAVE CARRIED SUSTAINED OUTPUTS & INCREASED USEFUL LIFE. CAPACITY AND OVERALL EFFICIENCY OF STEAM PLANT
13	HARD TO CLEAN		REQUIRES REPAIRS ABOUT EVERY YEAR	INCREASED CAPACITY, HAVE NOT REDUCED MAINTENANCE	150% AVERAGE

AMERICAN

AMERICAN ENGINEERING COMPANY, 2408 ARAMINGO AVENUE, PHILADELPHIA, PA.

an analysis of operating experiences with A-E-CO WATER WALLS •

OCTOBER 12, 1935, an outside organization began for us a survey to determine the experiences of our customers with A-E-CO water walls. Five questions were asked; to wit:

1. Have these walls given complete satisfaction?

2. What is your maintenance on water walls?

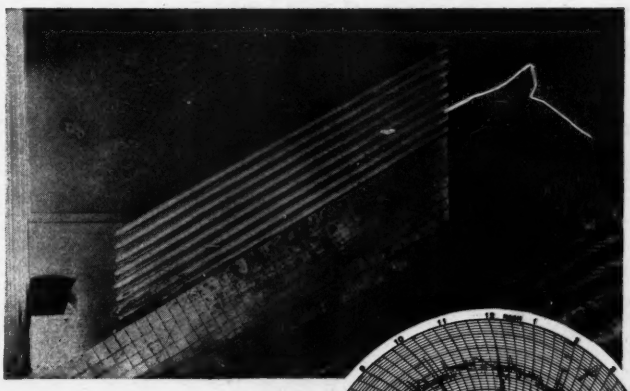
3. Has there been any refractory maintenance above the water walls?

4. Do you believe that the water walls have increased the steaming capacity of the boiler unit and reduced the maintenance of the Stoker?

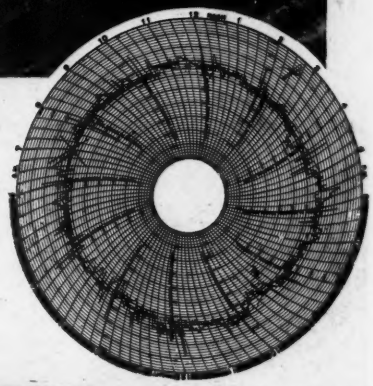
5. What is the average rating and length of service since the walls were originally installed?

In less than 3 weeks 13 replies were received. Excerpts from these responses appear in the table on the opposite page, without, of course, disclosing the identity of the company or the authority for the information.

The experiences of these representative plants, including central stations, institutions, industrial and municipal plants, are highly valuable to other operators. To us they are extremely gratifying and we heartily thank those operators, executives and managers who made the tabulations possible.



ABOVE: Water cooling for side walls of a high duty Taylor-stokered unit in a large central station. Upper bare tubes form a slag drip preventing slag from flowing onto lower armored section.



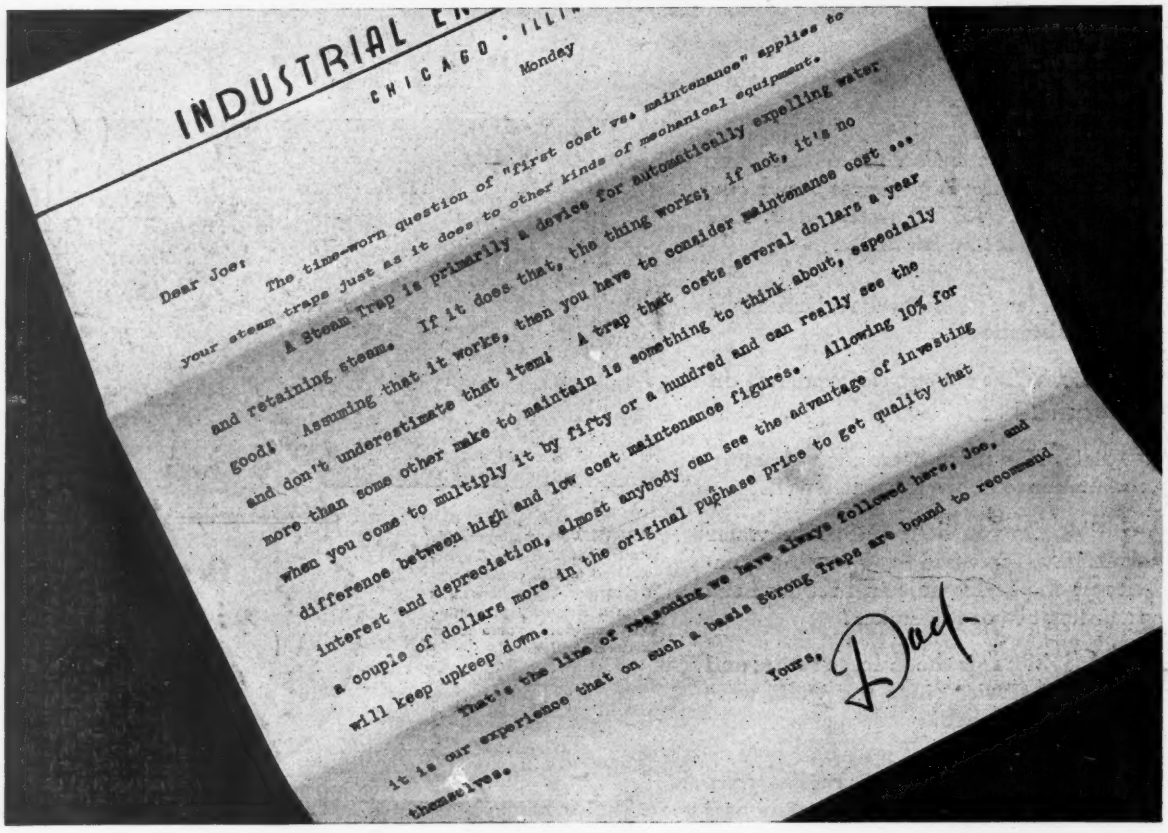
ABOVE: Recent boiler chart from Taylor-stokered, water-cooled furnace. Average boiler rating is 325% with long peak periods of 450%.

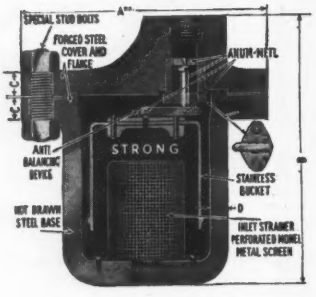
B. T. U. release averages 55,000 and reaches 75,000 for peaks of 24 hours duration.

LEFT: The application of A-E-CO water cooling to the side and rear walls of this central station Taylor-stokered furnace illustrates the possibility of revamping central station units to increase capacity and availability.

ANOTHER ADVERTISEMENT IN THE SERIES FEATURING LETTERS FROM

a Chief Engineer to his Son-


INDUSTRIAL
CHICAGO · ILLI
Monday
Dear Joe:
The time-worn question of "first cost vs. maintenance" applies to your steam traps just as it does to other kinds of mechanical equipment. A Steam Trap is primarily a device for automatically expelling water and retaining steam. If it does that, the thing works; if not, it's no good. Assuming that it works, then you have to consider maintenance cost ... and don't underestimate that item! A trap that costs several dollars a year more than some other make to maintain is something to think about, especially when you come to multiply it by fifty or a hundred and can really see the difference between high and low cost maintenance figures. Allowing 10% for interest and depreciation, almost anybody can see the advantage of investing a couple of dollars more in the original purchase price to get quality that will keep upkeep down.
That's the line of reasoning we have always followed here, Joe, and it is our experience that on such a basis Strong Traps are bound to recommend themselves.
Yours,
Dad-



The Strong Forged Steel Trap (80 Series)

Strong Traps always recommend themselves on their consistent record of keeping down your maintenance costs. Reasons why... rugged construction, simplicity of design, "Anum-metl" valves and seats (guaranteed leak-proof for one year)... assuring trouble-free service over years of operation.

Keeping down your maintenance costs with Strong Steam Traps is no happy accident. But the result of a constant purpose to win and keep the confidence of users everywhere... a purpose that has held for 30 years of successful experience in building steam traps (from the smallest size, which you can hold in the palm of your hand, up to the double, extra-heavy forged steel units suitable for pressures as high as 2,000 pounds)... to keep down your maintenance costs. Write for Bulletin No. 62-X.

THE STRONG-CARLISLE and HAMMOND CO.

1392 WEST THIRD STREET... CLEVELAND, OHIO

You can't deliver the goods

unless the Power Plant delivers the *"Juice"*

Increased production schedules for 1936 will put the brunt on your Power Plant. Can it take it?

With the expected increase in orders for 1936, this is an appropriate time to give new consideration to both production and power plant equipment. ★ Higher operating speeds, in many cases worn out machines, and the need for keeping every unit on the job—all suggest a re-checking of the efficiency of their lubrication. ★ For your turbines, Texaco Regal Oils will secure continuous top-performance under heavy loads. Used by turbine operators in all parts of the world, these high-quality oils have shown top-notch performance records. ★ For your manufacturing plant, there are Texaco Lubricants made especially for getting the most out of each and every unit, old or new, regardless of its particular requirements. ★ With exactly the right lubricant in each bearing you will be prepared for whatever demand is made upon you in 1936. Call in the Texaco representative. His friendly, cooperative counsel may save you money.

THE TEXAS COMPANY
135 East 42nd Street · New York City
Nation-wide distribution facilities assure prompt delivery

TEXACO *tested* LUBRICANTS

REFINERY TESTED FOR UNIFORMITY • • • SERVICE TESTED FOR ECONOMY

2 NEW data books on mechanical control

DATA BOOK No. S-11

Illustrates various methods for the mechanical control of pressures, flows, levels and speed. This Data Book describes in detail the new Smoot Series "50" (hydraulic) and Series "60" (pneumatic) regulators which will operate valves, dampers, rheostats, hydraulic couplings, or any type of variable speed transmission. The Smoot Series "50" and Series "60" regulators measure the quantity they control regardless of application and can be made sensitive to changes of less than 1/1000 of an inch of water.

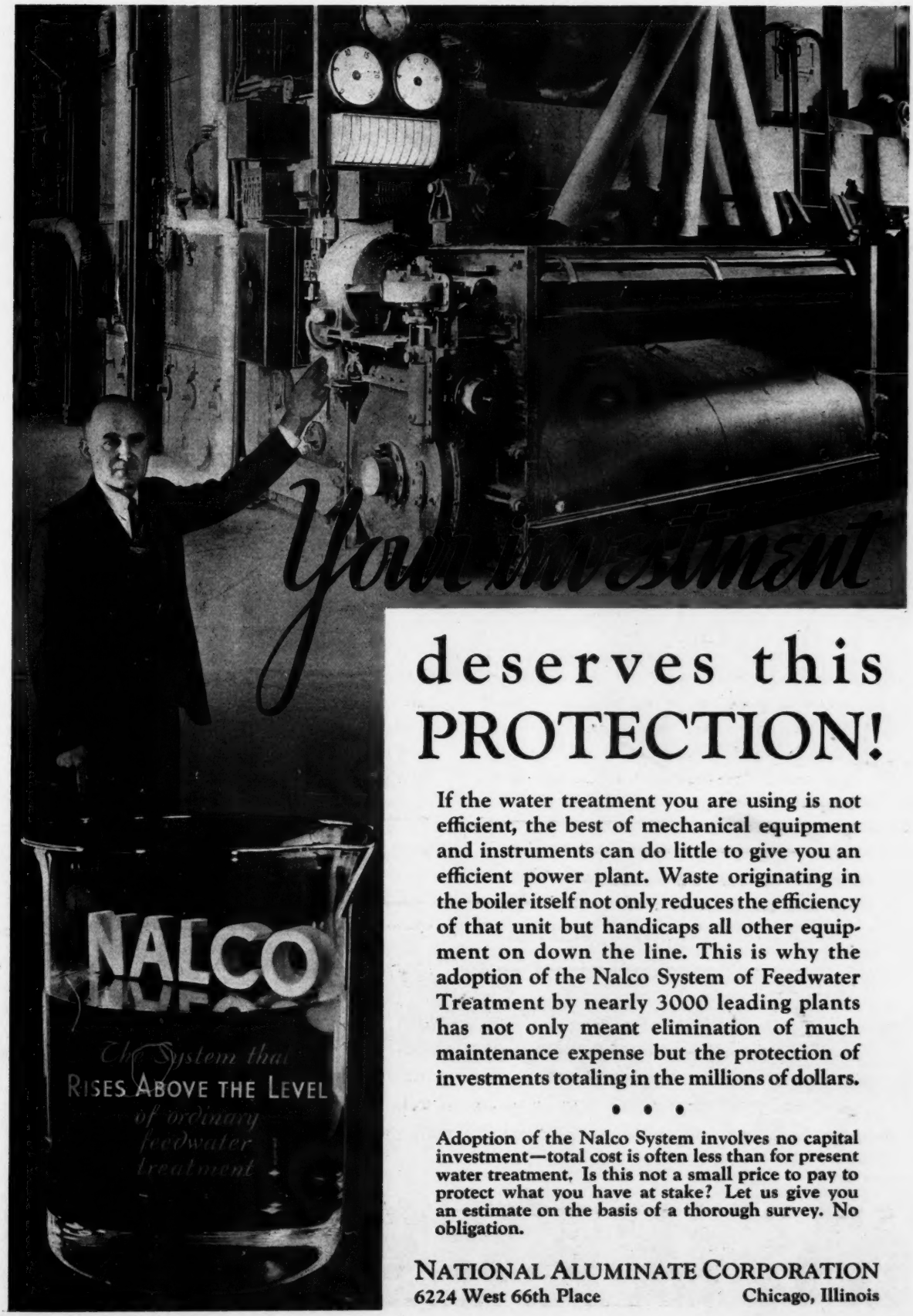
DATA BOOK No. S-20

Contains a complete discussion of the basic problems in boiler operation including—steam pressure control—combustion control—load distribution—and furnace draft control. This Data Book also discusses the difference between a control system and mere regulation; essentials of a successful mechanical control system, etc. It is fully illustrated and contains a large number of full page diagrams showing the application of the Smoot system of mechanical control to various types of boilers and fuel firing equipment.

Write for either or both of these Data Books — we will gladly mail them upon request, without obligation. They contain data of practical value to anyone interested in the subject of mechanical control. If you are having any operating problem, involving the control of pressure, rate of flow, level of a liquid, or speed of rotation, you will find these Data Books of unusual interest. Write for your copy today.

SMOOT ENGINEERING CORPORATION

Division of Republic Flow Meters Co.
2224 Diversey Parkway, Chicago, Ill.



Your investment deserves this PROTECTION!

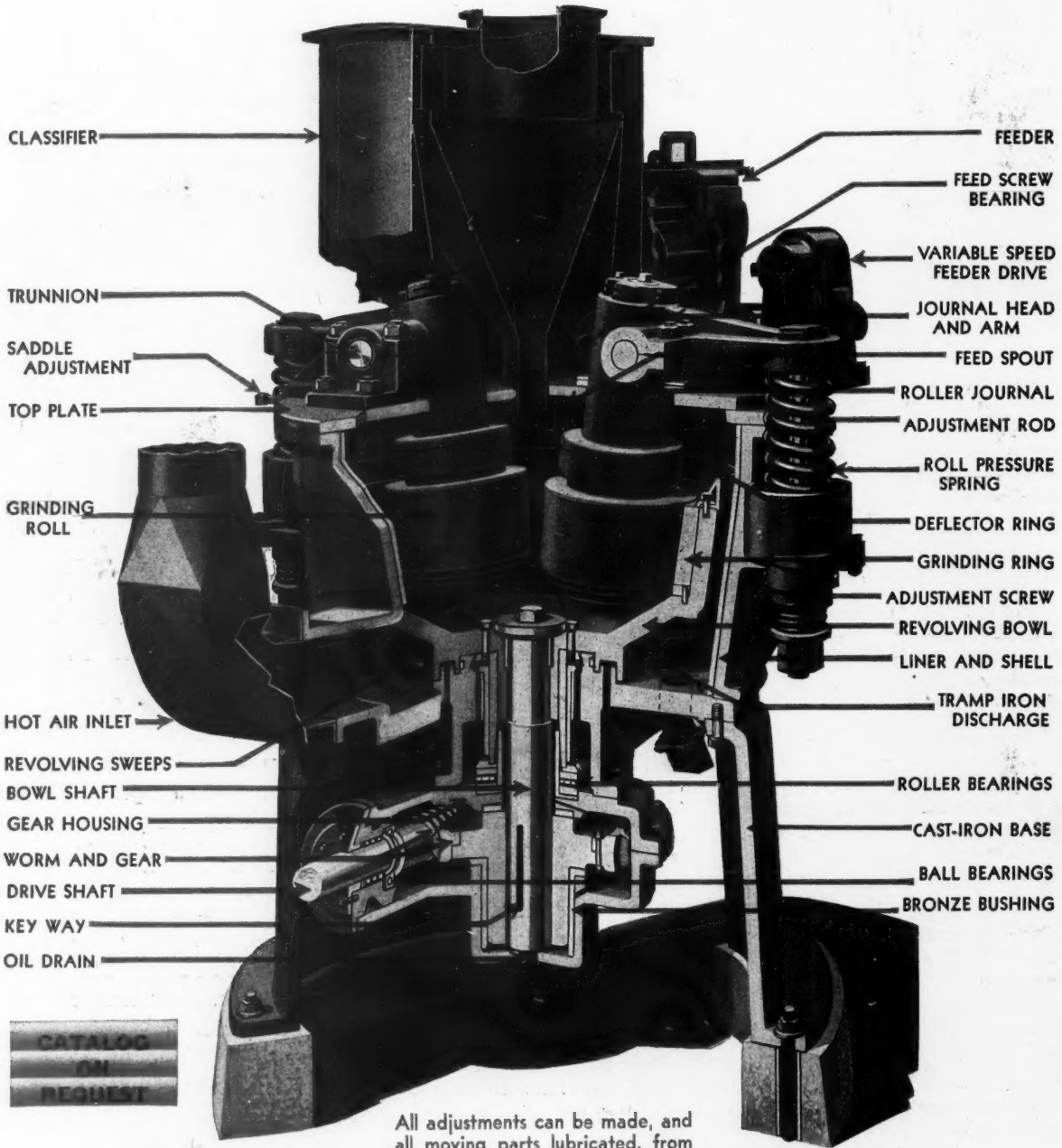
If the water treatment you are using is not efficient, the best of mechanical equipment and instruments can do little to give you an efficient power plant. Waste originating in the boiler itself not only reduces the efficiency of that unit but handicaps all other equipment on down the line. This is why the adoption of the Nalco System of Feedwater Treatment by nearly 3000 leading plants has not only meant elimination of much maintenance expense but the protection of investments totaling in the millions of dollars.

• • •

Adoption of the Nalco System involves no capital investment—total cost is often less than for present water treatment. Is this not a small price to pay to protect what you have at stake? Let us give you an estimate on the basis of a thorough survey. No obligation.

NATIONAL ALUMINATE CORPORATION
6224 West 66th Place **Chicago, Illinois**

ANNOUNCING



CATALOG ON REQUEST

All adjustments can be made, and all moving parts lubricated, from the outside, while mill is running

COMBUSTION

The RAYMOND BOWL MILL

A completely new design of mill providing for the first time the combined advantages of the impact or rotor type mill and the roller mill: the capacity range of the former and the power economy, low maintenance and other desirable operating features of the latter. Available in a range of sizes adequate for any pulverized fuel installation, either direct fired or storage type.

Several years ago the Raymond Brothers division of Combustion Engineering, specialists in pulverizing equipment for half a century, began development work with the objective of designing a mill which would have a capacity range adequate for direct firing of pulverized coal plus the operating and maintenance economy, continuity of service, uniform grinding and other features previously available only in mills of restricted capacity range.

The resulting design, the Raymond Bowl Mill, differs radically from any other mill on the market and provides a combination of features which places it in a class by itself.

The first commercial size Bowl Mill was built about a year ago and installed for test purposes in a large utility plant. Over long periods of continuous service and in special test runs this mill has demonstrated (1) that it realizes all the objectives of the design (2) that it has advanced present-day standards of coal pulverizer performance.

The outstanding feature of the Bowl Mill is a revolving bowl or grinding chamber with stationary journals, the grinding rolls of which are separated from the grinding ring by a distance of not less than $\frac{1}{16}$ in. As soon as the coal enters the grinding chamber, it is thrown by centrifugal force against the sides of the bowl where it is pulverized between the rolls and the grinding ring until fine enough to be picked up by the air stream at the top of the bowl and carried to the classifier.

It has been found that this principle of pulverization assures rapid and efficient reduction with virtually constant fineness over the entire range of capacity. The absence of metal-to-metal contact decreases wear and eliminates vibration and noise. Pulverization is accomplished with minimum power consumption and record low costs per ton.

Among the several orders received for the Bowl Mill in the short time it has been on the market is one from the Weirton Steel Company for four 12-ton mills for two 400,000-lb. steam generating units, and one from the Chevrolet Motor Company for four 5-ton mills for two 125,000-lb. steam generating units.

You will want to know more about the many interesting features of this latest development in pulverizers, so send for the new Bowl Mill catalog. . . . Combustion Engineering Company, Inc., 200 Madison Avenue, New York.

FEATURES

WIDE CAPACITY RANGE

Output can be varied in small increments from zero to maximum rating with practically constant fineness.

SIMPLIFIED OPERATION

Automatic feed, instantly adjustable. One standard constant speed motor for operating both mill and fan. Few parts and rugged construction insure freedom from mechanical troubles.

EFFECTIVE LUBRICATION

Positive oil circulation in main shaft bearings—gear mechanism running in oil—all operating parts lubricated from outside while mill is running

CONTINUITY OF SERVICE

Mill capable of operating continuously at full load, month after month, without shutdowns. All grinding adjustments may be made without stopping.

QUIETNESS

Elimination of metal-to-metal contact prevents pounding or vibration. Worm gear drive with ball bearings, main shaft with roller bearings and balanced operation insure quietness.

LOW MAINTENANCE

Few wearing parts have hardened steel wearing surfaces. Rolls work only on layer of material, never against metal. Adjustment feature aligns face of roll parallel with grinding ring regardless of wear.

LOW PULVERIZING COST

Due to low friction losses, Bowl Mill consumes less power. Worm gear drive permits use of high speed motor. New grinding principle assures rapid movement of material with resultant higher capacity and lower cost per ton.

C-E

A-247

Boiler Panel of Bailey Meter Air Operated Control System installed on 609 h. p. boiler burning lignite at Valley City Electric and Water Works, Valley City, N. D.

Profitable Modernization *Calls for* COMPLETE Combustion Control

• In addition to the purchase of new boilers and modern fuel burning equipment or the revamping of existing equipment, profitable boiler plant modernization calls for complete combustion control. Without this equipment losses resulting from inefficient operation may wipe out all hope for profit. With it you automatically secure test results in every-day operation.

Test results are secured with Bailey Meter Control because it is COMPLETE. It not only maintains steam pressure but also automatically readjusts fuel or air to constantly maintain maximum combustion economy. Constant control of fuel—air ratio and the accurate control of furnace draft reduces furnace maintenance to a minimum.

This complete combustion control system is described in Bulletin No. 102. Write for your copy today.

BAILEY METER CONTROL SYSTEM

BOILER METERS
COMBUSTION CONTROL
MULTI-POINTER GAGES
RECORDERS
FEED WATER CONTROL
SMOKE DENSITY RECORDERS
FLUID METERS

BAILEY METER COMPANY

1040 Ivanhoe Road Cleveland, Ohio

Bailey Meter Company Limited, Montreal, Canada A-11

BAILEY METER CONTROL

The **COMPLETE** *Combustion Control System*

USE YOUR FHA CREDIT

INSTALL PERMUTIT SELF-LIQUIDATING EQUIPMENT

PERMUTIT PRODUCTS

Equipment for Removing Hardness From Water:

(1) Zeolite Water Softeners.
(2) Hot Process Lime Soda Water Softeners.
(3) Continuous Lime Soda Water Softeners.
(4) Intermittent Lime Soda Water Softeners.
(5) Lime Barium Water Softeners.

Equipment for Removing Other Impurities Dissolved in Water:

(1) Zeolite Type Iron and Manganese Removal Filters.
(2) Chlorine (Free) Removal Filters.
(3) Taste and Odor Removal Equipment.
(4) Color Removing Equipment.
(5) Activated Carbon Filters.

Equipment for Removing Impurities Suspended in Water:

(1) Filters for Clarifying Water.
(2) Oil Removing Filters.
(3) Mechanical and Chemical Type Iron and Manganese Removal Filters.

Equipment for Feeding Chemical Solutions to Water:

(1) Automatic Apportioning Pressure and Gravity Feeds.

Continuous Blowoff Systems:

(1) For Boilers.
(2) For Evaporators.

Heat Exchangers

Ranarex Gas Density Machines:

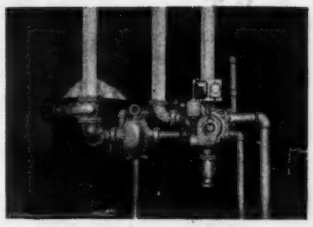
(1) For Determining CO_2 in Flue Gas.
(2) For Measuring Specific Gravity of Illuminating Gas.
(3) For Determining Ammonia in Ammonia-Air Mixtures.
(4) For Determining Specific Gravity and BTU in Butane Air Mixtures.
(5) For Other Applications Where Gas Density May be Used as a Guide to Operation.

● At last the means for plant modernization are available. The terms of the National Housing Act provide for loans up to $50,000 to responsible manufacturers in many classifications of industry. These loans are not made by the Government, but by your own banker, or they can be arranged through Permutit. The terms of payment allow gradual liquidation over a period of years.

Now you can purchase Permutit Water Conditioning Equipment. Permutit's record for savings proves that such equipment pays back its entire cost, usually within two years. Savings start immediately. That means that your monthly loan payments will be more than covered by the reduced operating costs effected by Permutit.

How does Permutit save money? Records of Permutit installations in more than 9,000 American power plants show that conditioned boiler feed water saves thousands of dollars yearly on turbining, tube replacement, and tube-failure expense. One large public utility saved $78,875 in a single year, more than $10,000 over and above the initial cost of its large installation of Permutit equipment!

Act now. Mail this coupon for complete details about this new plan. Just mention the type of equipment you are interested in, and complete descriptive literature will be sent you.



Permutit Automatic Zeolite Water Softener. Lowers the cost of producing soft water. No over-running. No under-regeneration. Automatic controls can be applied to existing equipment. Ask about the new greensand zeolite . . . Super-Zeo-Dur. Uses less salt and has a reserve capacity 75% greater than ever before.

Permutit
Water Conditioning Equipment

THE PERMUTIT COMPANY, Dept. A1, 330 W. 42nd St., New York City
Please send me, without obligation, complete details about the purchase of Permutit equipment under the terms of the FHA. I am particularly interested in the following Permutit products:

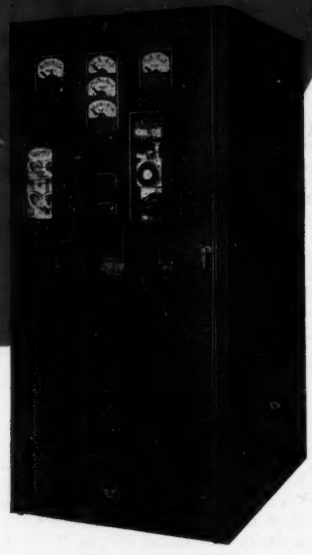
Name.....

Position.....

Company.....

Address..... City.....

WHY Gamble with Obsolete Switchgear?



YOUR switchgear should protect the economies of efficient generation. If it is obsolete —15 or 20 years old—the actual protection it affords may be less than you suspect; it may expose your operations to penalties—power outages, hazards to machinery and personnel—that can undermine the economies of the most efficiently run power plant.

REPLACE OBSOLETE SWITCHGEAR

It pays—in profits, in peace of mind—to put in modern G-E metal-enclosed switchgear. This equipment is tailored to your needs; it helps you deliver power to your production departments with minimum interruption. It requires little space; it is easy to inspect. It reduces machinery maintenance expense because of the better protection afforded. Installation entails no long delays in plant operation, since the equipment is completely assembled when you receive it.

A PROFITABLE INVESTMENT

An increasing number of power men are taking the gamble out of electrical protection by installing G-E metal-enclosed switchgear. Why not let us look over *your* plant and point out the advantages it will bring *you*? General Electric Co., Schenectady, N. Y.

820-15

GENERAL ELECTRIC

Four months ago—an already substantial sales volume. (Though, up to this time Yarway had not asked for business—preferred not to supply—wanted only to complete two years of field experience with some few thousand Yarway Traps quietly placed in Key plants, before offering these traps to the general public. But highly pleased users had re-ordered, had talked to friends about them.)

Today—three months after the first public announcement of this revolutionary steam trap—the demand is so far in excess of expectations that new automatic machines were inadequate even before they were installed. Tool orders had to be doubled—extra shifts added.

A demand so overwhelming that it has no precedent in Yarway history—few parallels in the history of any industrial product.

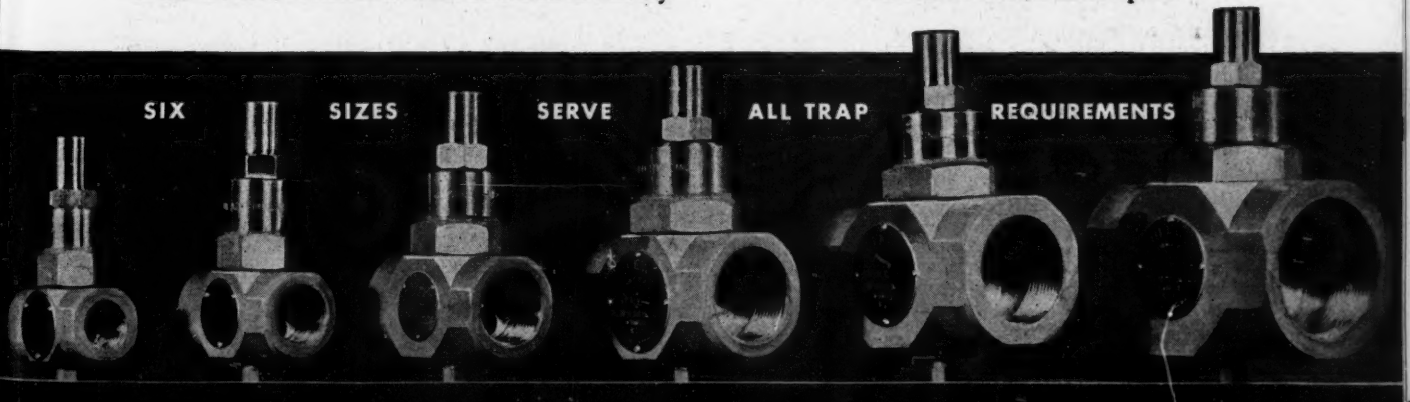
A demand that amazed even seasoned mill supply distributors—urged nearly fifty of them, to date, to take on the Yarway trap. Many of these are the leading houses in their territories. With distribution already extending from coast to coast, other mill supply houses are being attracted to the Yarway line in increasing numbers.

Why has this new steam trap caused the greatest stir in engineering circles—the greatest buying interest among trap users—not to mention the greatest increase in competitive advertising and selling pressure that the trap industry has seen for many a day?

Can there be any other answer than, whether it's a better mouse trap or a better steam trap—"the world will beat a path to your door"!

Ask your dealer about the Yarway trap which operates on an entirely new principle, is a fraction of the weight and size of an ordinary trap, has only one moving part, is practically universal in application to all trap needs. Or write for Bulletin T-1720 and name of nearest supply house. A trial will convince you.

YARNALL-WARING COMPANY
Mermaid Street, Philadelphia



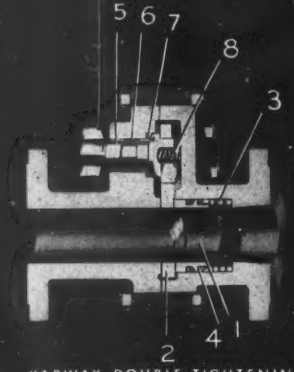
for

Fig. No. 3482-46. Iron body, bronze trimmed Yarway Double-Tightening Valve and Type B Seatless Valve in Tandem.

0 to 200 lbs.

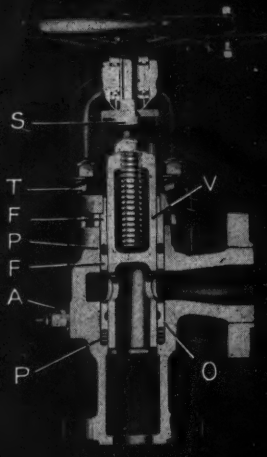
Fig. No. 3486-88. Steel body, bronze and Nitralloy trimmed Yarway Type B Seatless Tandem.

200 to 400 lbs.

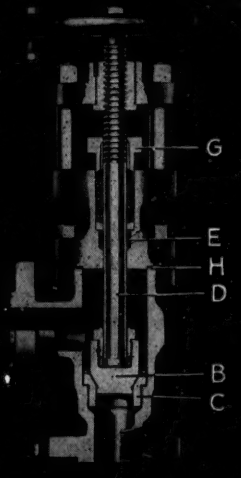


YARWAY DOUBLE-TIGHTENING VALVE (Fig. No. 3746)

(1) Sealing bushing. (2) Disc. (3) Sealing bushing spring. (4) Sealing bushing packing. (5) Stem. (6) Stem packing "A". (7) Stem packing "B". (8) Stem spring.



YARWAY TYPE C SEATLESS VALVE (Fig. No. 3910) Operation: After valve is closed, shoulder S on plunger V contacts with upper follower gland F, forcing it down into body and compressing packing P above and below port. Annular groove O connects with Alemite fitting A for lubricating plunger and packing. Yoke springs T maintain continuous pressure through follower glands F on packing rings P.



YARWAY HARD-SEAT VALVE (Fig. No. 3970) Disc B—Stellite-faced. Stainless Steel with lower lip to take wear and protect cone face. Seat C—Stainless Steel, heat treated and ground. Stem D—A.S.T.M. class C Steel. Condensing Chamber E is provided to insure relief of pressure before repacking stem stuffing box. Gland G is Bronze bushed to prevent cutting of stem. Bonnet Gasket Face H is serrated and Copper Gasket is used.

YARWAY BLOW-OFF

Every Pressure

In the complete line of Yarway Blow-Off Valves there is the answer to the particular blow-down valve requirements of every steam plant.

That is why there are over 10,000 satisfied users in 67 different industries—why Yarway Blow-Off Valves are regarded as a standard of quality by leading steam plant designers and builders of steam generating equipment.

Write for Catalog B-417. Sent on request.

YARNALL-WARING COMPANY
Mermaid St. Philadelphia

Fig. No. 3910-12. Steel body, Nitralloy trimmed Yarway Type C Seatless Tandem.

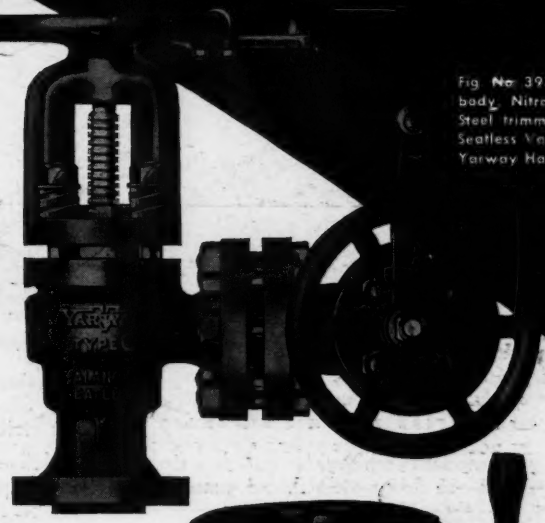


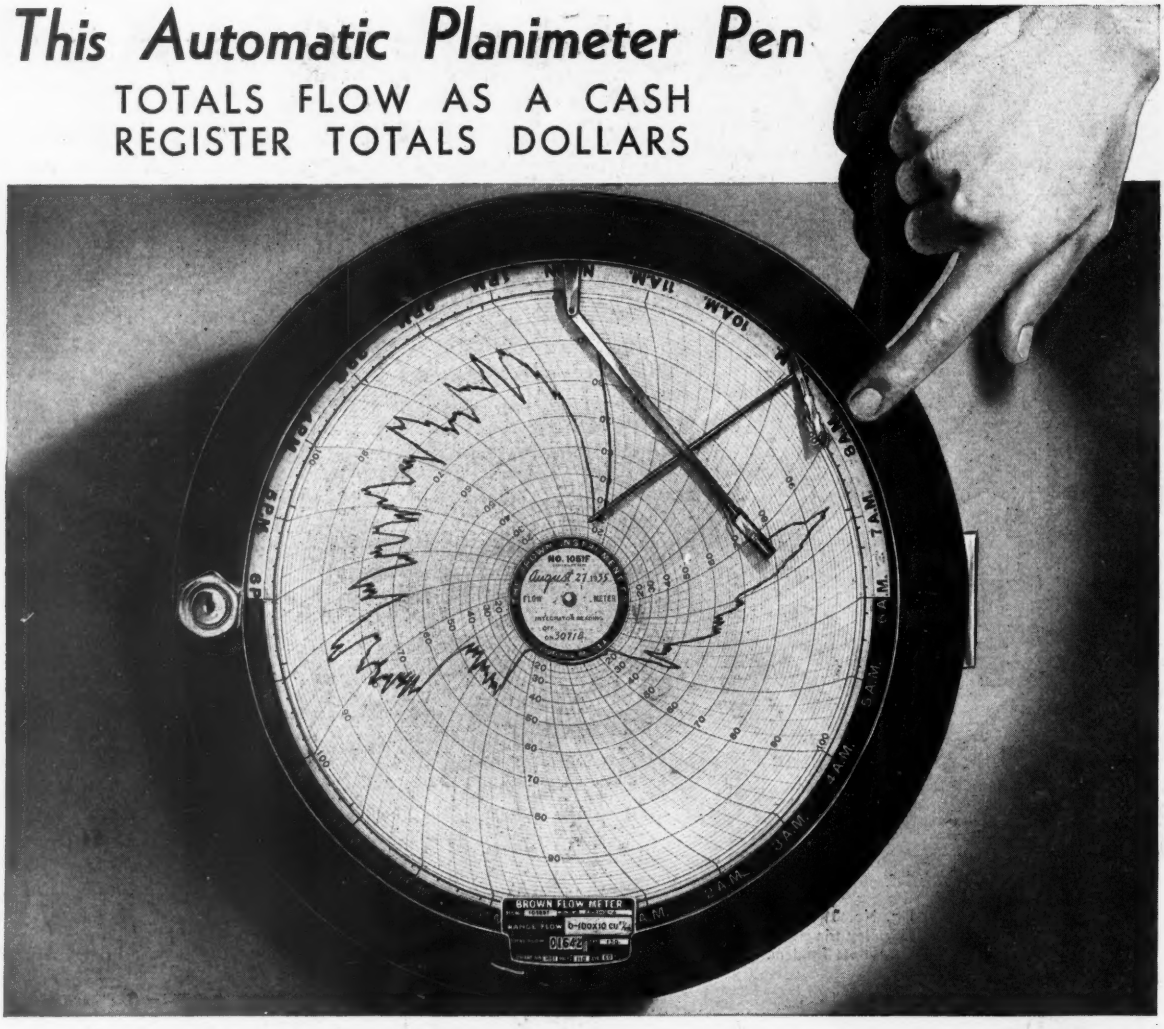
Fig. No. 3970-94. Forged steel body, Nitralloy and Stainless Steel trimmed Yarway Type C Seatless Valve in Tandem with Yarway Hard-Seat Valve.

Fig. No. 3982-58. Forged steel body, Nitralloy and Stainless Steel trimmed Yarway Unit Tandem—a Seatless and Hard-Seat Valve combination using one common forged steel body.

VALVES

This Automatic Planimeter Pen

TOTALS FLOW AS A CASH REGISTER TOTALS DOLLARS



Steam IS Money

Wasting steam boosts overhead—eats up income—shrinks profits. Steam accounting is serious business—it needs business methods.

As a modern cash register guards a storekeeper's dollars—producing a printed record of each transaction—so flow meters should guard your power and process steam.

MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS

MINNEAPOLIS-HONEYWELL REGULATOR CO. 1885-1935 125 YEARS OF PROGRESS 1860-1935 THE BROWN INSTRUMENT CO.

With Brown Flow Meters measuring the flow of steam for power, heating and processing, you are completely protected—because

The Brown Automatic Recording Planimeter Pen, making the marginal record shown on the chart pictured above, supplies the PROOF that a definite number of pounds of steam were delivered, utilized—or wasted.

This is a special, patented feature of the greatest value to flow meter users. Reference to the automatic planimeter pen record on chart rim assists you to distribute departmental or process loads more uniformly over the working day, effecting substantial fuel savings not only in the boiler room but in every department or unit where steam is used.

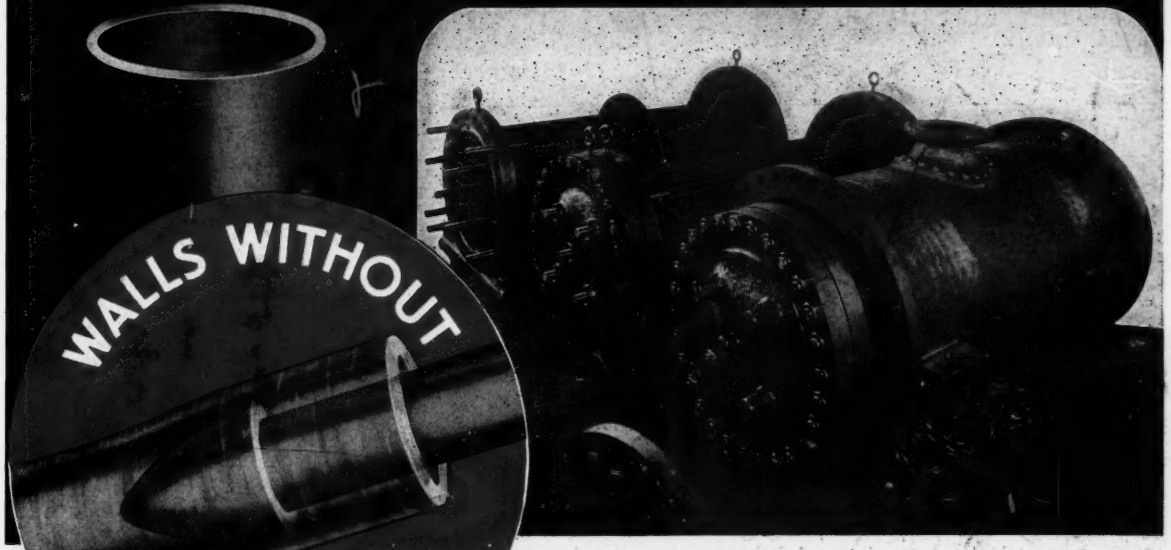
In the plants of leaders of industry such as American Woolen, National Biscuit, Fisher Body, Anaconda, American Steel & Wire, Remington Arms, DuPont, Firestone, National Tube and many others, Brown Flow Meters are proving their greater value.

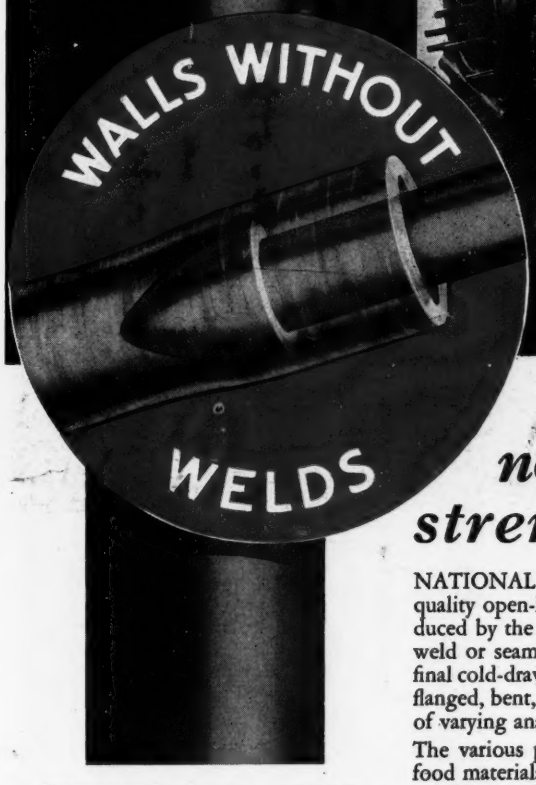
Get all the facts about Brown Flow Meters. Features are fully explained in Catalog No. 2003. BROWN INSTRUMENTS—a division of Minneapolis-Honeywell Regulator Company, 4491 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Canadian factory, 117 Peter Street, Toronto, Ontario, Canada.

BROWN FLOW METERS

Electrical and Mechanical

Be sure reliable tubes are used!





• • seamless tubes mean no welds—uniform wall strength, no uncertainty

NATIONAL Condenser and Heat Exchanger Tubes are made from the highest quality open-hearth or electric-furnace steel and are cold drawn from tubing produced by the piercing of solid billets. The walls, therefore, are entirely without weld or seam and structurally uniform and sound from end to end. After the final cold-drawing, tubes are heat-treated so they can be readily rolled into headers, flanged, bent, coiled or otherwise manipulated. For different requirements, steels of varying analyses are available.

The various products handled by modern heat transfer devices, from delicate food materials to the crudest vapors and liquids of large refineries, necessitate careful consideration in the choice of the tubes. Each different service may have a certain bearing on the physical and chemical property of the tube to be selected. NATIONAL engineers will gladly give advice in the choice of the best tubular material for the purpose intended. Correspondence is invited.

NATIONAL Condenser and Heat Exchanger Tubes are available in the following analyses of steel:

1. *Low Carbon Steel (Boiler Tube Grade).*
2. *Low Carbon Copper-Steel (0.20 to 0.35% Copper).*
3. *4-6% Chromium, 4-6% Chromium with Molybdenum, and Low Carbon Molybdenum Steels.*
4. *USS 18-8 (18% Chromium-8% Nickel) Stainless and Heat Resisting Steel*

NATIONAL TUBE COMPANY · Pittsburgh, Pa.

Pacific Coast Distributors—COLUMBIA STEEL CO., San Francisco, Calif.
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United States Steel Corporation Subsidiary

NATIONAL CONDENSER and HEAT EXCHANGER TUBES

7 ways

A RELIANCE ALARM ON YOUR BOILER WILL "EARN ITS SALT"

(AND SAVE YOUR BACON)

1. You can replace a broken gage glass in the safe assurance that your Reliance alarm is on the job while the boiler is "blind."

2. When you depend on a good automatic feed water regulator, you know your Reliance alarm is backing you up in case the water supply fails or a pump stops.

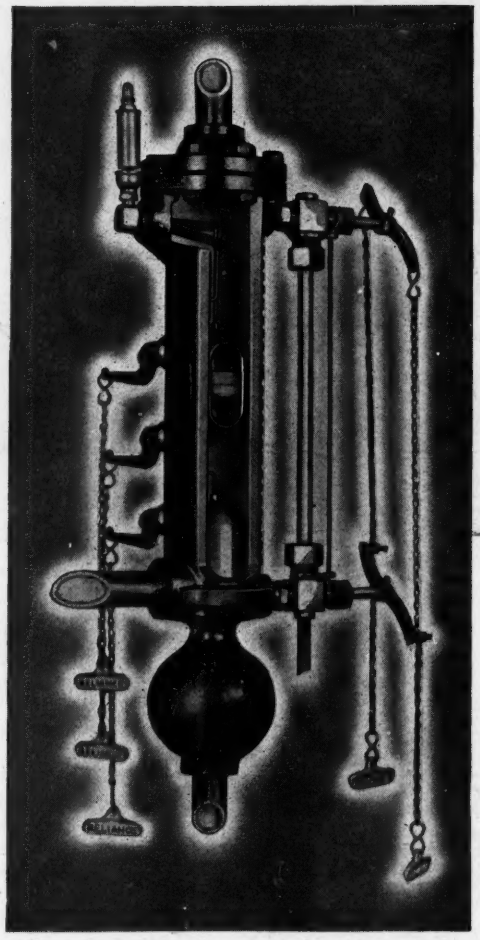
3. On hand-fed boilers the Reliance high and low alarm whistle is your alert assistant who never fails to remind you in plenty of time.

4. You can safely leave your Reliance protected boiler unwatched to attend to brief duties outside the boiler room.

5. A Reliance high and low alarm assures a more constant water level—therefore more economical power.

6. Your Reliance alarm spots those water surges for you promptly.

7. Even if a fire is started under a dry boiler, when someone has forgotten the water (and it's been done), the expanding air blows the Reliance whistle.



Reliance No. 5 boiler alarm, for high and low water. Instant action, simple direct mechanism, guaranteed unsinkable Monel Floats.

No two ways about it—a Reliance Alarm for as little as $1.58 a year (and it outlasts the boiler!) is not only sensible economy but an essential to safe operation.

Write for complete information.

THE RELIANCE GAUGE COLUMN CO., 5932 Carnegie Ave., CLEVELAND, OHIO

Reliance

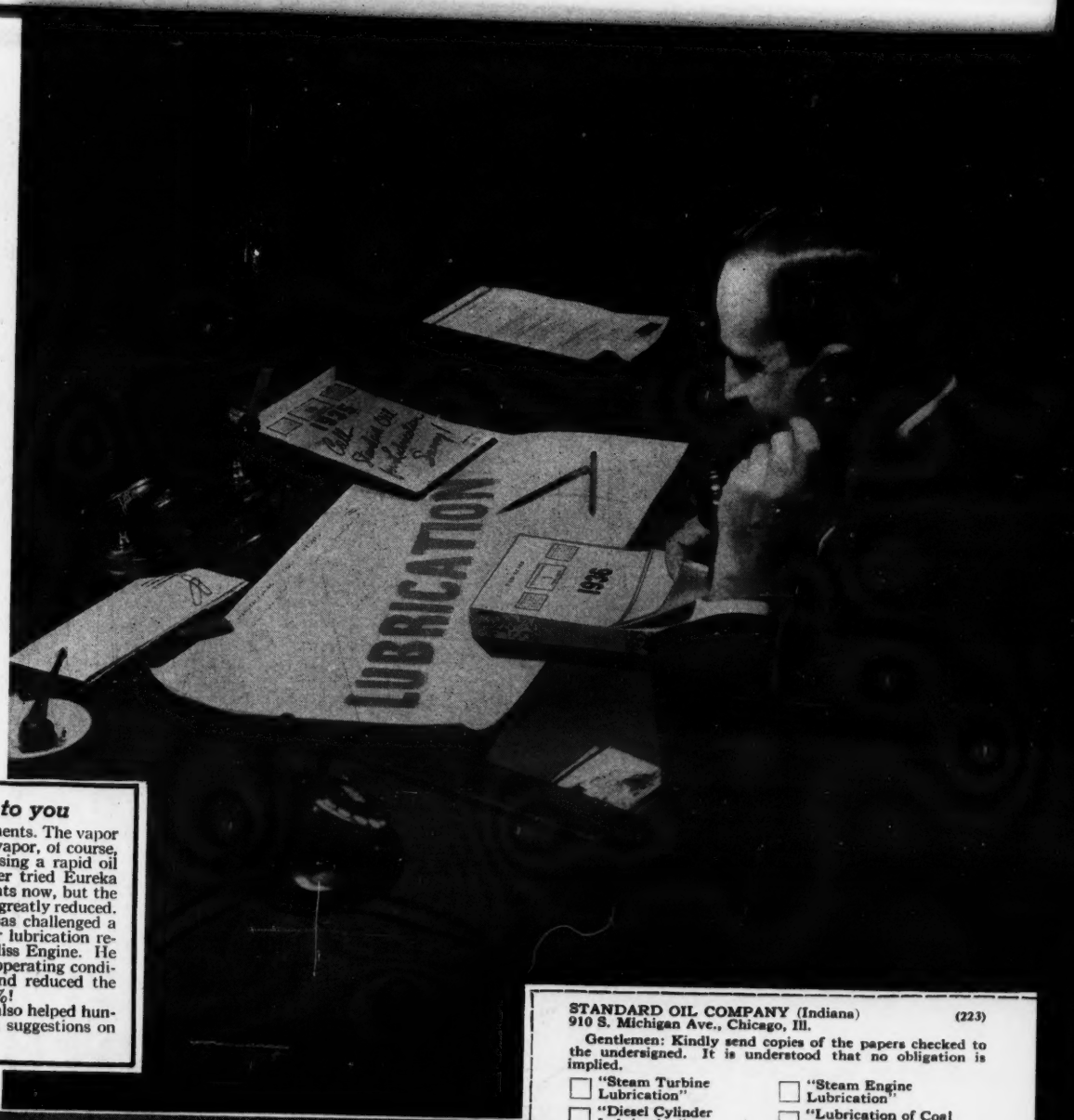
SAFETY WATER COLUMNS

Getting a Leap on LEAP-YEAR!

HE'S MAKING A CALL *NOW* THAT WILL MEAN 366 DAYS OF SAVING *NEXT YEAR*

● He's made a discovery. While studying his cost sheet carefully, he's found that lubrication costs can be traced in a lot of columns besides the one headed "Lubrication"; that they are written, in fact, clear across the cost sheet! He found a large item for repairs and labor, for instance, which he remembers was due to lubrication trouble. Right next to this, a much larger item, which was lost production while machines stood idle. He realizes that wear on machinery and maintenance costs must also be considered in total lubrication costs. That call he is making *now* is going to bring him savings that will spread through the whole next year. He is calling his local Standard Oil office.

Just a phone call to *your* local Standard Oil office will bring you the Lubrication Engineer and the assurance that nothing more can be done to lower lubrication costs in your plant. Correct Lubrication is his specialty, and Correct Lubrication *reduces costs* and accumulates savings *day by day!* His service implies no obligation whatever. So get a leap on Leap-Year *now!*



. . . and it can happen to you

Joe couldn't read his switchboard instruments. The vapor from the engine oil was too heavy. The vapor, of course, was due to evaporation, which was causing a rapid oil consumption. The Standard Oil Engineer tried Eureka Engine Oil. Joe could read his instruments now, but the important thing was that the oil feed was greatly reduced.

The chief engineer of a plant in Kansas challenged a Standard Oil Engineer to produce better lubrication results than he was getting on a large Corliss Engine. He said it couldn't be done. After studying operating conditions, the engineer used Stanooyl "D" and reduced the oil consumption from then on exactly 50%!

Standard Lubrication Engineers have also helped hundreds of plants cut costs simply through suggestions on lubrication methods or equipment.

Copr. 1935, Standard Oil Co.

STANDARD OIL COMPANY (INDIANA)

CORRECT LUBRICATION

STANDARD OIL COMPANY (Indiana) (223)
910 S. Michigan Ave., Chicago, Ill.

Gentlemen: Kindly send copies of the papers checked to the undersigned. It is understood that no obligation is implied.

- ☐ "Steam Turbine Lubrication"
- ☐ "Steam Engine Lubrication"
- ☐ "Diesel Cylinder Lubrication"
- ☐ "Lubrication of Coal Handling Equipment"
- ☐ "Diesel Engine Air & Fuel Cleaning"
- ☐ "The Lubrication of Diesel Air Compressors"
- ☐ "Diesel Engine Bearing Lubrication"
- ☐ "The Lubrication Engineer—His Value to You"

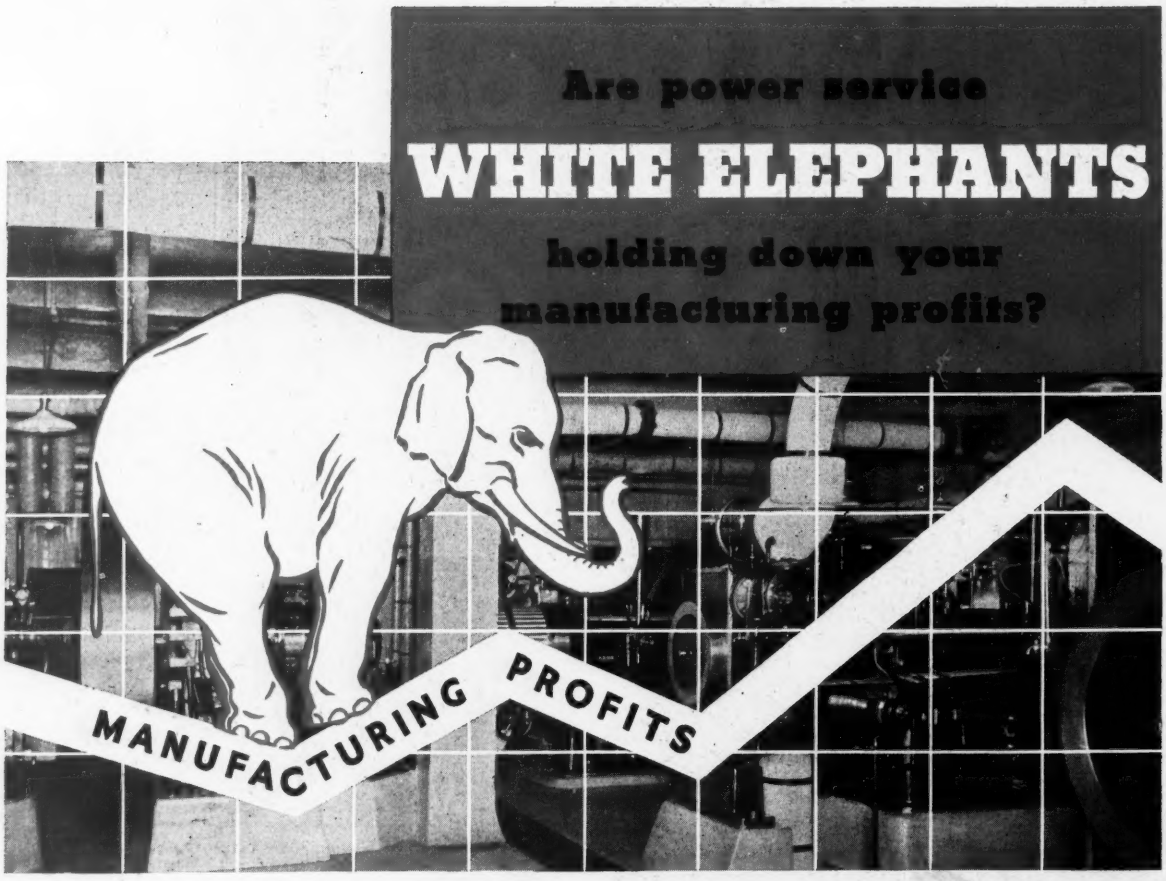
Name .....

Position .....

Company .....

Address .....

City ..... *State* .....



In hundreds of power plants over ten years old, obsolete "White Elephant" boilers, engines, compressors, traps, pumps, piping or other units are wasting up to 50 cents of each dollar spent for power services. These power leaks are a constant barrier to increased manufacturing profits.

Have you staged a systematic "White Elephant" hunt recently in your plant? Do you actually know which power service units are assets or liabilities? Have you made an unbiased study of your methods for generating, transmitting and utilizing power with a view to improving the service and strengthening profit margins?

Many engineers and plant managers have found the answers to such questions through consultation with Austin Engineers. Such a study will help determine whether your present plant can be profitably modernized or whether new construction is most advantageous. Whatever the answer may be Austin is organized to carry on the entire operation from preliminary recommendations to steam in the boilers.

Telephone or write your nearest Austin office. This consultation involves no obligation.

THE AUSTIN COMPANY

ENGINEERS AND BUILDERS • Cleveland, Ohio • 16112 Euclid Ave. • Telephone GLenville 5400

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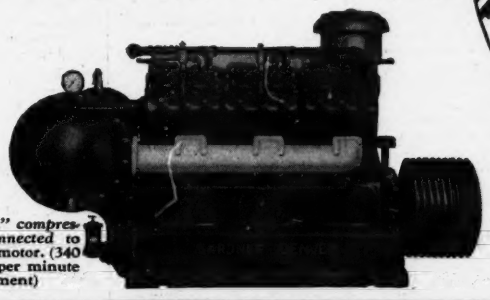
THE AUSTIN METHOD

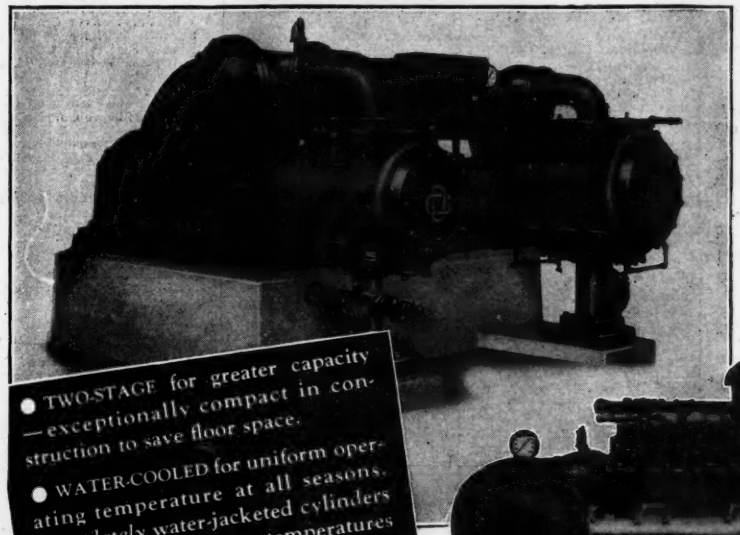
POWER SAVINGS YOU CAN COUNT

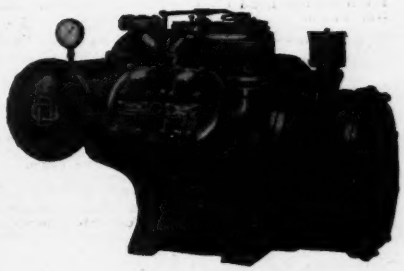
Because they embody generations of manufacturing experience—because they are so far ahead in design—the Gardner-Denver Products shown here give you definite, COUNTABLE power savings. You can readily prove this—in your own plant.



(below) "HA" compressor direct-connected to synchronous motor. (340 to 975 cu. ft. per minute displacement)

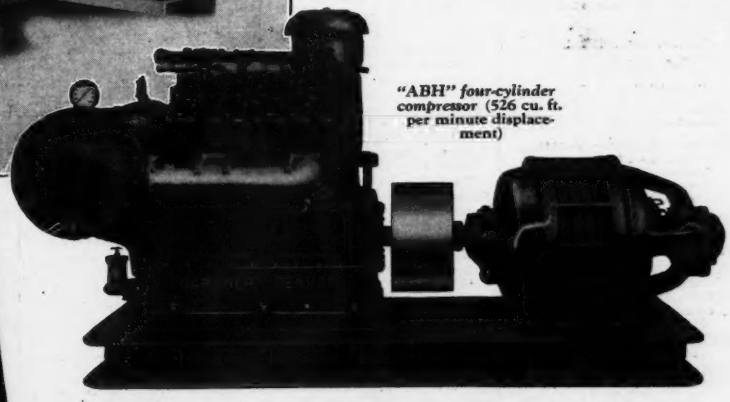
"ABJ" six-cylinder compressor (790 cu. ft. per minute displacement)





"WB" six-cylinder compressor (226 to 445 cu. ft. per minute displacement)

- TWO-STAGE for greater capacity—exceptionally compact in construction to save floor space.
- WATER-COOLED for uniform operating temperature at all seasons. Completely water-jacketed cylinders assure cooler discharge temperatures—better lubrication—longer compressor life.
- Compressors may be direct-connected to electric motor, thus eliminating belts and belt friction losses.
- Brass Tube, water-cooled intercooler saves power by efficiently cooling air between stages.
- Famous for durability and long life.



"ABH" four-cylinder compressor (526 cu. ft. per minute displacement)

GARDNER-DENVER COMPANY

SINCE 1859

102 WILLIAMSON STREET **QUINCY, ILLINOIS**

GARDNER-DENVER

MAKES AIR DO MORE AND COST LESS

Machinery, Equipment and Supplies Used in The Production, Transmission and Utilization of Power

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De Laval Steam Turb. Co.
Gardner-Denver Co.
General Electric Co.

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Combustion Engrg. Co.

Bearing
National Tube Co.

Blowers, Fan and Furnace
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De Laval Steam Turb. Co.
Sturtevant Co., B. F.

Blowers, Tube
Bayer Company
Diamond Power Specialty Corp.

Blowers, Turbine
Elliott Co.
Moore Steam Turb. Corp.
Terry Steam Turbine Co.

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National Aluminate Corp.

Boiler Compounds
Monsanto Chemical Co.

Boiler Feed Water Purifying Apparatus
Permutit Co.

Boiler Setting Cement
Carborundum Co., The
Eagle-Picher Lead Co.
Norton Co.

Boiler Settings
Carborundum Co., The
Norton Co.

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Combustion Engrg. Co.
Frick Co.
Wickes Boiler Co.
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Builders, Power House
Austin Co.

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Republic Flow Meters Co.

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Hays Corporation, The
Republic Flow Meters Co.

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Hays Corporation, The
Permutit Co.
Pierce Co., Wm. B.
Republic Flow Meters Co.

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Smooth-On Mfg. Co.

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Elliott Co.
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Hays Corporation, The
Pierce Co., Wm. B.
Republic Flow Meters Co.

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Corning Glass Wks.
Ernst Water Col. & Gage
Jenkins Bros.

Gauges, Recording Pressure
Foxboro Co.
Hays Corporation, The

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Meters, Coal
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Meters, Water and Steam
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Squires Co., C. E.
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Vogt Machine Co., Henry

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Crane Company
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Stokers, Underfeed
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Thermometers, Dial
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Thermometers, Recording and Indicating
Brown Inst. Co.
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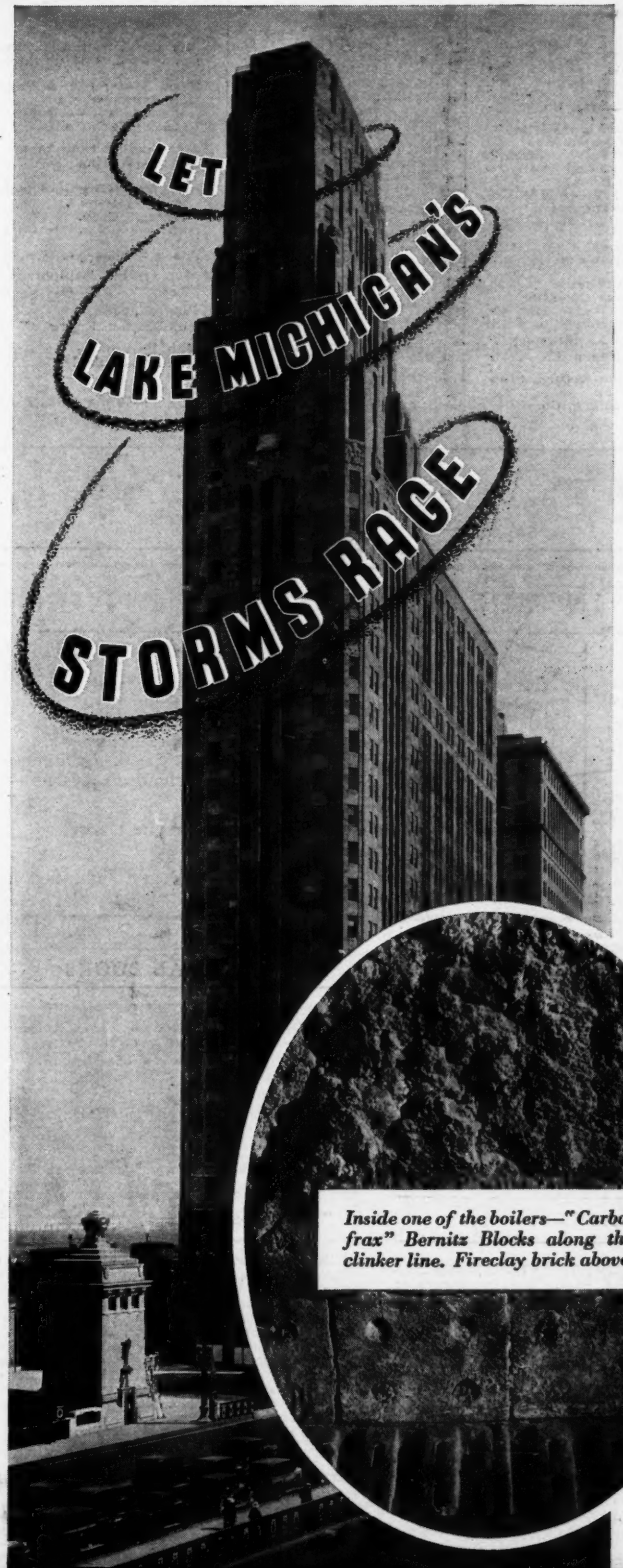

Inside one of the boilers—"Carbofrax" Bernitz Blocks along the clinker line. Fireclay brick above.

BOILER SHUTDOWNS FOR REFRACTORY REPAIRS ARE UNKNOWN . . . .

HEATING the No. 333 N. Michigan Avenue Building, Chicago, places a severe burden on the boiler equipment. It faces directly on Lake Michigan. It is exposed to varying and severe weather conditions. Boiler shutdowns are serious and everything possible is done to eliminate them.

"Carbofrax" Bernitz Blocks were installed when the boilers were set in 1929 and have served without any trouble or repair work through six severe heating seasons. The blocks are in such good condition that several more seasons' use is expected of them.

The first cost of such an installation is higher than that of ordinary refractories but the annual cost is considerably lower. And boiler shutdowns for refractory repairs are unheard of.

TUNE IN THE CARBORUNDUM BAND
Saturdays at 7:30 P.M., E.S.T.
Columbia Chain

District Sales Branches: Boston, Chicago, Cleveland, Detroit, Philadelphia, Pittsburgh. Agents: L. F. McConnell, Birmingham, Ala.; Christy Firebrick Company, St. Louis; Harrison & Company, Salt Lake City, Utah; Pacific Abrasive Supply Co., Los Angeles, San Francisco, Seattle; Denver Fireclay Co., El Paso, Texas; Williams and Wilson, Ltd., Montreal-Toronto, Canada. (Carborundum and Carbofrax are registered trade-marks of The Carborundum Company.)

"CARBOFRAX"
REG. U. S. PAT. OFF.
The Carborundum Brand
Silicon Carbide Refractory

BRICK • TILE • MUFFLES • CEMENTS • HEARTHS

THE CARBORUNDUM COMPANY
Refractory Division Perth Amboy, N.J.

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Armstrong Machine Wks
Strong, Carlisle & Hammond Co.

Traps, Steam, Radiator and Return
American Dist. Steam Co
Armstrong Machine Wks
Sarco Co., Inc.
Strong, Carlisle & Hammond Co.
Yarnall-Waring Co.

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Liberty Mfg. Co.
Pierce Co., Wm. B.

Turbines, Hydraulic
Allis-Chalmers Mfg. Co
De Laval Steam Turb. Co

Turbines, Steam
Allis-Chalmers Mfg. Co
De Laval Steam Turb. Co
Elliott Co.
General Electric Co.
Moore Steam Turb. Corp
Terry Steam Turbine Co
Sturtevant Co., B. F.

Underground Heating Systems
American Dist. Steam Co
Johns-Manville Corp.

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Garlock Packing Co.
Jenkins Bros.

Valves, Auto. Cut-Off
Edward Valve & Mfg. Co

Valves, Back Pressure
Foster Engrg. Co.

Valves, Blow-Off
Crane Company
Edward Valve & Mfg. Co
Fairbanks Co., The
Jenkins Bros.
Lunkenheimer Co.
Yarnall-Waring Co.

Valves, Check
Crane Co.
Edward Valve & Mfg. Co
Fairbanks Co., The
Jenkins Bros.
Kennedy Valve Mfg. Co.
Williams Valve Co., D. T

Valves, Elec. Operated
Fairbanks Co., The
Frick Co.

Valves, Float
Foster Engrg. Co.

Valves, Gate and Globe
Crane Company
Edward Valve & Mfg. Co
Fairbanks Co., The
Jenkins Bros.
Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Strong, Carlisle & Hammond Co.
Vogt Machine Co., Henry
Williams Valve Co., D. T.

Valves, Hydraulic
Fairbanks Co., The
Kennedy Valve Mfg. Co.
Vogt Machine Co., Henry

Valves, Lever Balanced
Foster Engrg. Co.

Valves, Non-Return, Stop and Check
Foster Engrg. Co.

Valves, Pop Safety
Crane Company
Lunkenheimer Co.

Valves, Plug
Fairbanks Co., The

Valves, Pump
Garlock Packing Co.
Jenkins Bros.

Valves, Radiator
American Dist. Steam Co
Crane Company
Fairbanks Co., The
Kennedy Valve Mfg. Co.
Williams Valve Co., D. T

Valves, Reducing, Regulating and Relief
Chaplin-Fulton Mfg. Co.
Cochrane Corp.
Edward Valve & Mfg. Co
Foster Engrg. Co.
Squires Co., C. E.
Strong, Carlisle & Hammond Co.

Valves, Steel
Crane Company
Edward Valve & Mfg. Co.
Kennedy Valve Mfg. Co.

Ventilating Apparatus
Burt Mfg. Co.
Sturtevant Co., B. F.

Waste Heat Recovery Systems
Babcock & Wilcox Co.

Water Columns and Alarms
Diamond Power Spec. Corp.
Ernst Water Col. & Gage
Lunkenheimer Co.
Reliance Gauge Col. Co.
Yarnall-Waring Co.

Water Cooling Equipment
Yarnall-Waring Co.

Water Purifying and Softening Systems
Cochrane Corp.
National Aluminate Corp
Permutit Co.
Scaife & Sons Co., Wm. B

Water Testing Equipment
National Aluminate Corp

Water Walls
Combustion Engrg. Co.

Weigh Larries
Richardson Scale Co.

Whistles
Lunkenheimer Co.

SIGNBOARD SECTION

RATES FOR ADVERTISING IN THE SIGNBOARD SECTION

CLASSIFIED RATES

Advertisements published in the Signboard Section which come under the classifications of "Positions Wanted"—"Engineers Wanted"—"Salesmen & Agencies"—"Patent Attorneys"—etc., are charged for by the line.

The rate per line for one insertion is—50c

The minimum advertisement accepted is four lines. Classified advertisements are all printed in the same style and sizes of type. No display type is used. Box numbers can be used. Replies are forwarded promptly.

DISPLAY RATES

The unit of space used for advertisements under the headings of "Equipment Wanted"—"Equipment for Sale"—"Technical Books"—"Professional Cards"—etc., is the column-inch which is one column (2¼ in.) wide and one inch deep. The basis rate is $5.50 for one column-inch in one issue. This basis rate decreases as larger space is used.

Quotations will be sent promptly on request for any desired size of space or number of insertions.

Display headings, bold-face or italic type and signature cuts are permissible in Display Advertisements.

EQUIPMENT FOR SALE

FOR SALE

1—Vert. Electric Generator
2400 volts—60 cycles—3 phase—85 KVA —200 RPM—P.F. 1.00 Cont. Vertical Shaft Type Z Leffel—Size 24"—120 Rated HP—9 to 13 ft. head water wheel. Belted Exciter E.M. Co. 125 volt—6½ K.W.—One 2500 ft. lb. Woodward Governor.

1—Vert. Electric Generator
2400 volts—60 cycles—3 phase—165 KVA —150 RPM—P.F. 1.00 Cont.—Vertical Shaft Type Z Leffel—Size 33—230 Rated HP—9 to 13 ft. head water wheel. Belted Exciter E.M.Co. 125 volt—11 K. W.—One 3000 ft. lb. Woodward Governor.

1—4 Panel Switch Board with Breakers—Instruments and Voltage Regulator.

GEO. A. HORMEL & CO.
Austin, Minn.
T. H. Hocker, Purchasing Department

ENGINE GENERATOR SETS.

KVA	Generator	Engine	Location
120 (2)	G. E.	Ames Uniflow	Miss.
175 (2)	G. E.	Ames Uniflow	N. Y.
180	G. E.	Chuse Uniflow	Miss.
250	G. E.	Skinner Uniflow	N. Y.
275	G. E.	Ridgeway 4 v.	Penna.
312 (2)	G. E.	Skinner Uniflow	Ohio
350	Wghse.	Hamilton Corliss	N. Y.
400	G. E.	Erie Ball 4 v.	Penna.
625	G. E.	Ames Uniflow	N. Y.
750	G. E.	Erie City Lentz	Minn.

TURBINES, BOILERS, MOTOR GENERATOR SETS, ETC.

Power Plant Equipment Co., Inc.
39-41 Cortlandt St., New York, N. Y.

EQUIPMENT FOR SALE

We have a 150 h.p., 125 pound pressure Erie City HRT boiler with three year old Pulverzone Stoker and enough spare grates for complete renewal. Will trade on large water softener or engine generator set 150 to 175 KW, 3 phase, 60 cycle, 240 volts A.C.

CANTON LAUNDRY AND CLEANING CO.,
Canton, Ohio.

PATENTS

IMPROVED AUTOMATIC STOKER ON GAS PRODUCER PRINCIPLE. The Proprietors of British Patent No. 417070 relating to "Improvements relating to Furnaces" are desirous of entering into negotiations with interested parties in Canada with a view to the exploitation of the invention either by sale of the patent rights or by the granting of licenses on reasonable terms. All enquiries should be addressed to Hartley & Sugden Ltd., Halifax, England.

PATENT YOUR INVENTION PROMPTLY, PROPERLY, Attractively, through a thorough, Long-experienced Patent Attorney. Registered in U. S. Patent Office 29 years (No. 7780). Free Patent Book and Blanks. Sterling Buck, Permanent Loan Bldg., Washington, D. C.

SALESMEN AND AGENCIES

REPRESENTATION WANTED for established specialty line, Cushioned Noiseless Check Valve —Applicant state qualifications, accounts handled and territory covered. Address Box 1233, c/o Power Plant Engineering, 53 West Jackson Blvd., Chicago, Ill.

TECHNICAL BOOKS

MECHANICS MATHEMATICS

GOOD NEWS! PRACTICAL MATHEMATICS ILLUSTRATED. EVERY MECHANIC can use the new correct easy methods covering a complete review of practical arithmetic, with examples, including mensuration—plane and solid geometry trigonometry — algebra — calculus — ELECTRICAL AND MECHANICAL SHOP CALCULATIONS—practical tests—reference tables and data how to use the slide rule—700 pages—850 illustrations—pocket size. Highly endorsed. Let us mail you copy for free trial. Price $2. postpaid.

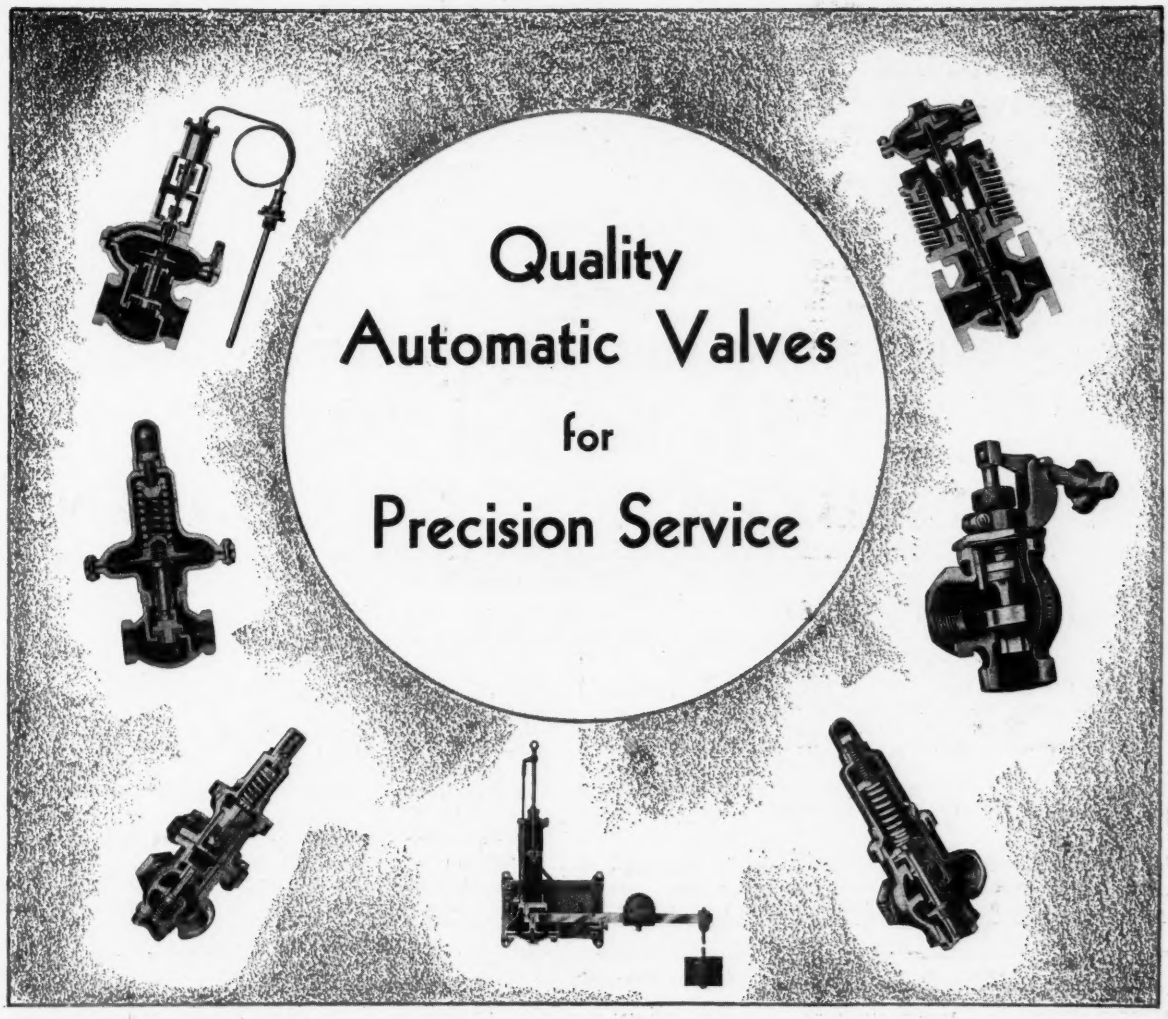
Theo. Audel & Co., 65 West 23d St., New York

ENGINEERS WANTED

WANTED:—Power Maintenance Foreman in large modern industrial power plant in New York State to take charge of maintenance, repair and new installation work on high pressure boilers, stokers, turbines, refrigeration machines and auxiliary equipment. Broad experience in this work required, as well as operating experience for stationary engineers license qualifications. This position is understudy to the Chief Boiler and Turbine Room Operating Engineer. In reply, give full information as to training, experience, and salary expectations. Attach inexpensive photograph to your letter. Box 1234, c/o Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

POSITIONS WANTED

SUPT. OF MAINTENANCE. A man thoroughly experienced in keeping plants and large buildings in top-notch condition. Broad background covers practical knowledge of construction work, carpentry, masonry, plumbing, electric wiring, painting, interior decorating. Also executive experience in managing a staff, figuring costs, keeping maintenance records and inspection schedules. Is seeking position as Supt. of Maintenance for a large school or college. Please address inquiries to Box 1226, c/o Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.



AUTOMATIC VALVES
FOSTER
EST. 1879 · ENGINEERING CO.

Pressure Regulators
Relief Valves
Hydraulic Pressure Regulators
Hydraulic Relief Valves
Damper Regulators
Non-Return Valves
Fan Engine Regulators

THE Automatic Valve is a *control unit* upon which not only operations largely depend but often safety itself. Only the best Automatic Valves should be used because only the best will have the strength of materials, the accuracy of machining, the precision of operations necessary for safety and quality service.

Foster Automatic Valves are in this class. They have back of them more than 50 years' experience. You are on sound ground when you buy them.

AUTOMATIC VALVES
FOSTER
EST. 1879 · ENGINEERING CO.

Vacuum Breakers
Temperature Regulators
Altitude Valves
High Pressure Regulators and Relief Valves
Pump Governors
Strainers
Sight Flow Boxes

FOSTER ENGINEERING CO.

106 Monroe St., Newark, N. J.

Shortening The Gap Between Invention and Utilization

When Mark Twain was editing a western newspaper, a merchant wrote asking whether a spider in his morning newspaper was an omen of good or ill fortune.

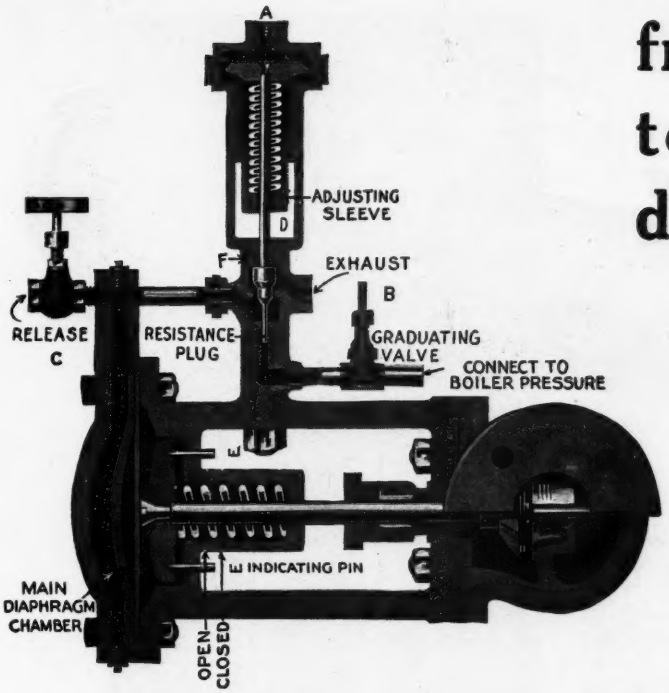
Mark replied as follows: "A spider in your paper did not mean either good or bad luck for you. He was merely looking to see which merchants advertised, so that he could go to the store of one who did not do so, build his web over the door and remain peaceful and undisturbed for the rest of his days."

Advertising is more than a symbol of progressiveness. It is recognized by manufacturers and merchants as an effective, economical selling tool. It helps spread information about new products—what they are, how they work and how they can save. It shortens the gap between invention and utilization.

Through the advertising pages of POWER PLANT ENGINEERING alert manufacturers and their engineers are making important contributions to the onward march of the power plant industry. They are constantly recording the latest improvements in boilers and belting, pumps and piping, motors and meters. They are using the force of advertising to simplify and reduce the cost of selecting power plant equipment.

Consider the advertisements in POWER PLANT ENGINEERING as convenient and reliable buying bulletins. Read them regularly to compare the performance values of equipment and supplies. Read them to smooth out operating problems and to reduce power costs.

THE BYSTANDER



from *all* pressures to *any* pressure down to ounces in one operation

SQUIRES Reducing Valves

A Positive Dead End Valve

No matter how difficult the service may be, Squires Reducing Valves deliver the necessary pressure. Simple construction and easy accessibility of working parts insure the Squires Valve's continuous and accurate performance.

Control of this valve is by a pilot valve which is governed by the low pressure side. Delivery pressure is independent of the high pressure side and its maintenance is certain. Operation is automatic when the pilot valve is set.

The durability and sensitivity of Squires Patented Diaphragms, which are used in all Squires Reducing Valves, Pump Governors and Boiler Feed Water Controllers, add to the superiority of Squires operation.

Complete details about the Squires Line may be had on request. Consult our engineers.

Send for Catalog E-1-10.

Other Genuine Squires Steam Specialties

Standard Genuine Squires Steam, Air and Blast Traps

New Genuine Squires Steel Trap

Class "E" Pump Governor
Class "H" Pump Governor
Class "B" Excess Pump Governor

Boiler Feed Water Controller

Insist on the Genuine **Squires** **Steam Specialties**

TRADE MARK

THE C.E. SQUIRES COMPANY — E. 40TH ST. & KELLEY AVE., CLEVELAND

A Length of Rusty Pipe

—and what it led to

A LESSON FOR MANUFACTURERS

A SHORT length of wrought iron pipe removed from the boiler feed line was shown to the Cochrane engineer who had been called into consultation by a textile manufacturer. The pipe had been in service but eight months and already active corrosion had set in.

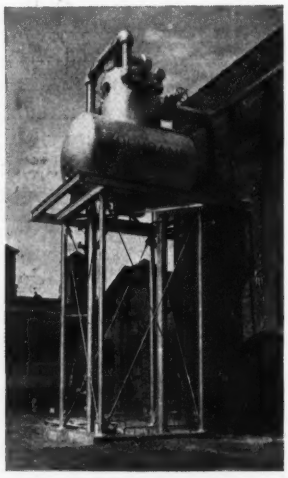
Investigation showed that while the water supply for the raw make-up was excellent in quality, it had a low hardness content coupled with a comparatively high CO_2 content, resulting in a pH value of 6.7, which is actively corrosive of wrought iron or even brass.

A Cochrane Deaerating Heater was recommended to liberate oxygen and CO_2, and simultaneously bring about a raising of the pH value. However, this could not be installed at once, as changes were being made progressively, and a Cochrane 120,000 lb. per hr. Bleeder Closed Heater was first installed to replace an older heater.

Later the Cochrane Deaerating Heater was installed, along with a new motor centrifugal boiler feed pump, and the closed heater was then used as a 60 lb. bleeder heater.

The results of this installation have been highly satisfactory, corrosion being completely eliminated.

Detailed information about Cochrane Deaerating Heaters is contained in Bulletin No. 700. A copy will be mailed on request.



Photos by courtesy of the Millville Manufacturing Company, Millville, N. J., show their Cochrane Deaerating Heater combined with a large hot water storage tank. The advantage of this arrangement with respect to availability of water directly preceding pumps is obvious.

These Deaerating Heater and Tank combinations are built in any desired heating capacity and with whatever water storage volume is desired.

COCHRANE CORPORATION, Dept. B-10, 17th & Allegheny Ave., PHILADELPHIA, PA.

COCHRANE

WATER SOFTENERS • DEAERATING HEATERS • FILTERS • BLOW-DOWN EQUIPMENT • VALVES • FLOW METERS

"In Stock"

even on Industry's Frontiers

MANY people never heard of Hoquiam, in the great lumber region of Washington... or the busy little oil town of Sour Lake, Texas... or Sylacauga in cotton-growing Alabama. Yet in these and a hundred more outposts of Industry Jenkins Valves are favored, and stocked by local supply houses.

Only a few Branded products are of such reputation that they may be obtained *from the shelves* of stores on Industry's Frontiers as well as in its centers. That Jenkins Valves are numbered among the few is a convincing demonstration of their merit. It takes more than ordinary quality and efficiency in a product to win such a universal demand among buyers.

Speedy delivery from a stock that, practically speaking, is "just around the corner" makes Jenkins Valves as convenient to buy as they are profitable to use. One of the twelve hundred leading supply houses carrying complete stocks of "Jenkins" is right near you... ready to provide what you want WHEN you want it... capable of saving your time and money in many ways.

Jenkins Bros

JENKINS BROS., 80 White Street, New York, N. Y. 510 Main Street, Bridgeport, Conn.; 524 Atlantic Avenue, Boston, Mass.; 133 No. Seventh Street, Philadelphia, Pa.; 822 Washington Boulevard, Chicago, Ill.; JENKINS BROS., Ltd., Montreal, Canada; London, England.

JENKINS VALVES • SINCE 1864 BRONZE • IRON • STEEL

STOP OXYGEN CORROSION

Eliminate oxygen from your boiler feed water and protect your metal surfaces simply, economically and efficiently with SANTOSITE.

Ask us to tell you more about the advantages and especially about SANTOSITE for boilers in stand-by service.

Monsanto Chemical Company
ST. LOUIS, U.S.A.

NEW YORK • CHICAGO • BOSTON
SAN FRANCISCO • MONTREAL

SEND FOR THE WHOLE STORY

MONSANTO CHEMICAL COMPANY
1700 South 2nd St., St. Louis, Mo.

Please send us your leaflet and tell us more about SANTOSITE as insurance against Oxygen Corrosion.

Name _____

Address _____

City _____ State _____

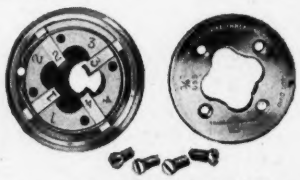
BOLT THREADS—

AND HANGER RODS are easily and quickly threaded with the new "TOLEDO" Adjustable Bolt Die Heads.

Standard bolt threads or an over or under adjustment of 1/64" are readily obtained by loosening the four die head cover screws and turning the knurled ring until the dies are set to the desired size.

Made in the following sizes either U.S.S. or S.A.E. thread. ⅜", 7/16", ½" or 9/16" at $3.35 and ⅝", ¾", ⅞" and 1" at $3.50 net F.O.B. Toledo, Ohio, or dealers' stocks.

Each die head is cadmium plated. Order now from your regular dealer.



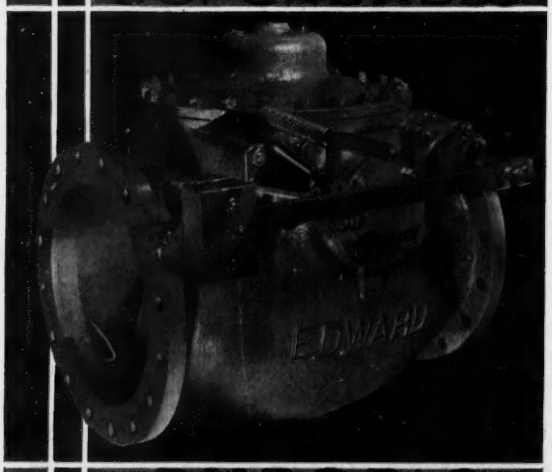
THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO NEW YORK OFFICE, 72 LAFAYETTE ST.

"TOLEDO"

SPECIFY "TOLEDOS"

EDWARD BACK PRESSURE VALVES

DEPENDABLE

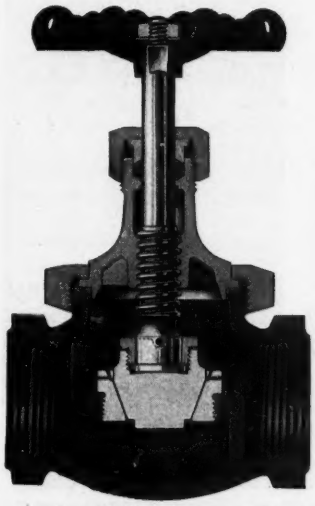


DURABLE

The Edward Valve & Manufacturing Co., Inc.
EAST CHICAGO, INDIANA

~long bearing contact

like a cork in a bottle

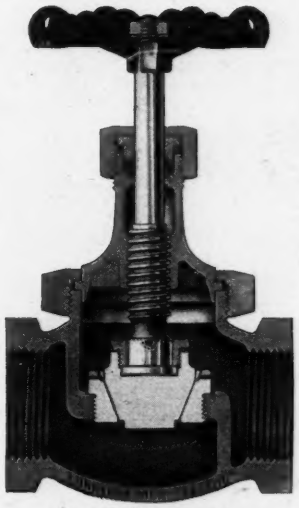


Iron Body "Ferrenewo"
Fig. 1021-P, 150 lb. SP.

LUNKENHEIMER

PLUG TYPE

"FERRENEWO" and "RENEWO" VALVES



Bronze "Renewo"
Fig. 73-P, 200 lb. SP.
Fig. 16-P, 300 lb. SP.

for Throttling, Drain, Drip, Water Column Blow Down and other Severe Service also preferred by some users for General Service

- The plug type disc is deep-seated and ground into its own seat, to a uniform bearing from end to end. Each plug is properly tapered with long bearing contact to fit snugly into its seat—*just like a cork in a bottle*—providing a fit as perfect as can be made to insure a tight seat and satisfactory service.

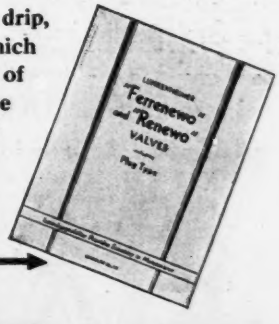
- "NS5" Alloy (patented in U. S.) the material of which the seat and disc are made is a new and exclusive Lunkenheimer research development. It is a non-ferrous composition of uniformly great hardness (300 Brinell) and retains its hardness at high temperatures. "NS5" will not gall; it is resistant to wear, abrasion, erosion and corrosion.

- Most valve users have troublesome throttling, drain, drip, water column blow down and other severe service which play havoc with seats and discs. With the combination of correct design and "NS5" seating material, Plug Type Valves approximate as closely as possible a satisfactory solution to these problems.

Available through the local Lunkenheimer distributor.

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U.S.A.
NEW YORK CHICAGO BOSTON
PHILADELPHIA SAN FRANCISCO
EXPORT DEPT. 318-332 HUDSON ST., NEW YORK

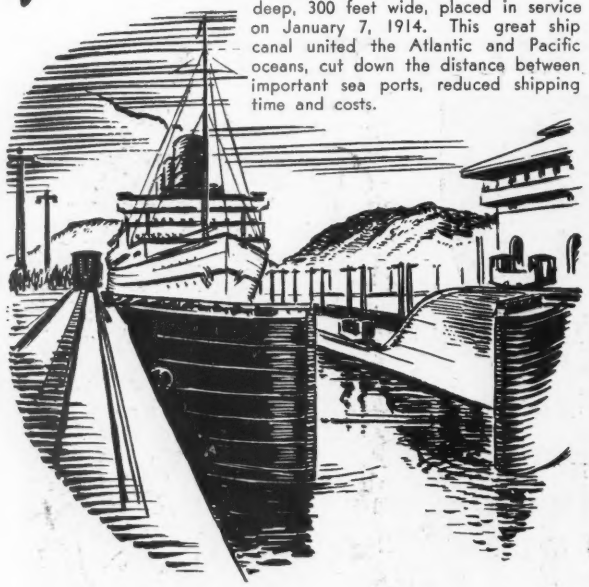
The interchangeability of parts between Plug Type and Full-Way "Renewo" and "Ferrenewo" Valves is explained in the new booklet F 541. May we send you a copy?



BOILER MOUNTINGS — LUNKENHEIMER VALVES — LUBRICATING DEVICES

102-72PB-44

famous UNIONS in history



Panama Canal, 50.5 miles long, 45 feet deep, 300 feet wide, placed in service on January 7, 1914. This great ship canal united the Atlantic and Pacific oceans, cut down the distance between important sea ports, reduced shipping time and costs.

DART Unions pay an equally important part in transporting steam, oil, gas, water and other media through industrial plants safely and at low cost. . . . Dart Unions stay leakproof because they are made with non-corroding, bronze-to-bronze seats. Darts also have extra heavy malleable iron nuts and pipe ends that will not crack or stretch. Once in place in the pipe line, they do their work without further attention. . . . Standardize on Dart Unions in your plant and save many needless piping repairs. Darts come in shapes and sizes for all piping needs — are sold by leading jobbers everywhere. Write today for descriptive booklet.

E. M. DART MFG. CO.
Providence, R. I.

Sales Agents: The Fairbanks Company, New York, and all branches. Canadian Factory: Dart Union Company, Ltd., Toronto, Canada

DART
The BRONZE-TO-BRONZE *Union*

"find them the best" SAY THOUSANDS OF USERS

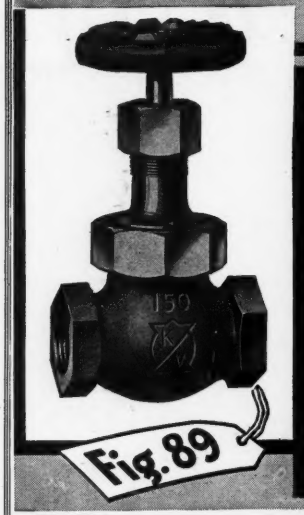


Fig. 89

TWO generations of valve users have known Kennedy Valves to be skillfully designed and honestly made. That is why so many thousands of engineers and contractors will use only valves with the KV trade mark — the shield that assures satisfactory service. Profit by the experience of these men and standardize on Kennedy Gate, Globe, Angle and Check Valves for steam, water, air, gas or oil service.

THE KENNEDY VALVE MFG. CO.
Elmira, N. Y.

KENNEDY
VALVES-PIPE FITTINGS-FIRE HYDRANTS
BUY KENNEDY PRODUCTS FROM YOUR LOCAL DEALER

ELECTRICITY

What It Is and How It Acts

by Andrew W. Kramer

In two volumes, 582 pages, 5½x8, 242 illustrations, $4 postpaid

"An excellent series of articles on the nature of electricity. It is most readable by those who think they know what it is all about and by those who admit they don't know much about electricity. The illustrations are excellent and quite frequently are of the simple and graphic form that many writers seem afraid to use. We recommend the book highly."
Review in RADIO BROADCAST

This book tells in simple language all that is known about electricity today. It explains what it is, how it produces various effects we are familiar with, what magnetism is, how light waves and X-rays are produced, what radioactivity is. Yet it is not fanciful; it deals only with known and accepted theories, presenting them simply and straightforwardly so that those not mathematically minded can understand them. It is this unusual treatment of a scientific subject that has won the favor of both the technical engineer and the layman.

In Volume I the electron as the fundamental basis for electrical phenomena is considered almost entirely with respect to itself. Volume II deals with radiation phenomena—the part played by the electron on propagation of light, the radiation of heat and radio waves.

TECHNICAL PUBLISHING CO.
53 W. Jackson Blvd., Chicago, Ill.

"Just Around the Corner"

AMERICA'S INDUSTRIES FIND CRANE STOCKS

● Crane service in valves, fittings, and piping is a *localized* service. Within 24 hours of every factory in the United States, and within one to two hours of a great majority of them, complete stocks of Crane valves and fittings are available.

The Crane line is extensive, capable of answering the daily requirements of the 209,348 industrial establishments within the service areas where Crane stocks are carried.

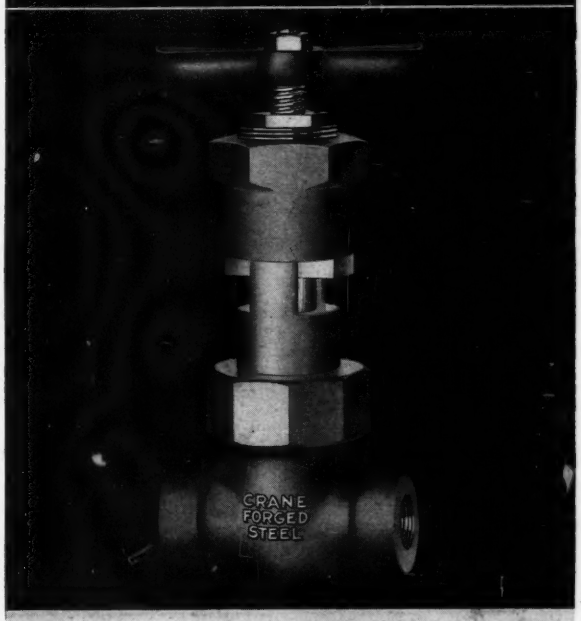
Crane materials will help you solve any piping problem. If extensive modernization is contemplated, the Crane Finance Plan allows you to spread the cost over a period of years.

CRANE SHOP FABRICATION SERVICE

Design — Flanging
Casting — Cutting
Bending — Threading
Welding — Assembling

There is a Crane Valve or Fitting for every piping requirement

UNIQUE



Crane 216-P Forged Steel Globe Valve

1 A compact, serviceable, and moderately priced valve for severe service at high pressures and temperatures—600 pounds at 750° F. and 1500 pounds at atmospheric temperature.

2 A scientifically designed plug type disc adapts this valve for throttling, blow down, soot blower, and drip and drain line service.

3 Width and angle of seating surface gives long service life but does not restrict flow or permit disc to wedge in seat.

4 The unique design of this outside screw and yoke type globe valve provides serviceable working parts throughout.

5 Seats and discs are regrindable.

CRANE

CRANE CO., GENERAL OFFICES: 836 S. MICHIGAN AVE., CHICAGO, ILLINOIS • NEW YORK: 23 W. 44TH ST.

Branches and Sales Offices in One Hundred and Sixty Cities

CRANE VALVES, FITTINGS AND PIPE FABRICATION

PROTECTED TOP SEAT ASSURES A CLEAN TIGHT JOINT WHEN VALVE IS OPENED FOR RE-PACKING UNDER PRESSURE.

THE HEAVY, ROLLED-BRONZE ROD STEM HAS AN AVERAGE STRENGTH OF 65,000 LBS. MORE THAN 5 THREADS ARE ALWAYS IN CONTACT WITH BONNET.

THE STRONG BRONZE UNION NUT WITH LARGE HEXES OFFERS A FIRM WRENCH GRIP AND PERMITS REMOVAL OF BONNET WITHOUT DAMAGE.

RADIAL SEAT INSURES A TIGHT JOINT AND PERFECT ALIGNMENT OF PARTS WHEN NEW DISC IS INSERTED. NO SLIDING OR SCRAPING OF SEATING SURFACES.

DISC IS AN IMPROVED COMPOSITION OF ASBESTOS AND WILL NOT CRACK OR FLAKE OFF IN STEAM OR HOT OR COLD WATER SERVICE.

SLIDE-ON DISC HOLDER WILL NOT BIND OR STICK REGARDLESS OF POSITION OF VALVE. ANY STANDARD MAKE OF RINGS FIT THIS HOLDER.

TRY TO MATCH THESE IMPORTANT FEATURES OF

Fairbanks Renewable Valves

The greater number of vital features in Fairbanks Valves, plus sturdy construction, accounts for their more enduring quality, low upkeep cost and reliable performance at all times. They are quality products through and through. Write for our new Catalog No. 21

THE FAIRBANKS COMPANY

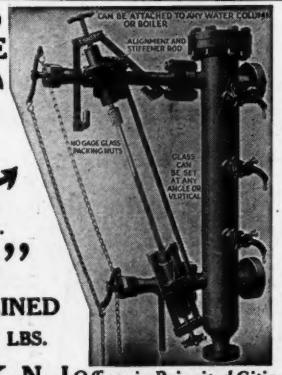
Manufacturers of Valves, Hand Trucks and Wheelbarrows.

399 Lafayette St., New York, N. Y.

Boston, Pittsburgh—Distributors in Principal Cities

LEAKLESS COCKS

SPLIT-GLAND GAGES HAVE NO


CAN BE ATTACHED TO ANY WATER COLUMN OR BOILER
ALIGNMENT AND STIFFENER ROD
NO GAGE GLASS PACKING NUTS
GLASS CAN BE SET AT ANY ANGLE OR VERTICAL

ERNST High Pressure GAGE GLASS

GASKETS

Gage Glass GUARDS

Safety at All Pressures

Write for Catalog B

SPECIFY

GAGE GLASS PACKING NUTS

ROUND GLASSES FOR 1000 LBS.

ERNST "SPLIT-GLAND"

ADJUSTABLE WATER GAGES, VERTICAL or INCLINED

COLUMNS & TRY COCKS FOR PRESSURES UP TO 2000 LBS.

ERNST WATER COLUMN & GAGE CO., NEWARK, N. J. *Offices in Principal Cities*

ARE YOUR BOILERS STRIPPED FOR ACTION?

They are not, if scale deposit is gripping their tubes.

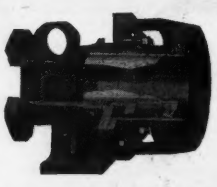
A Dean Cleaner will remove every particle of scale, inside or outside, easily, quickly, efficiently. It will eliminate all deposit—strip the power plant of scale—strip it for action!

There is a Dean for every cleaning job.

Write for Free Bulletin—Now

The William B. Pierce Co., 149 Ellicott St., Buffalo, N. Y.

ADSCO EXTERNALLY GUIDED JOINT



The Expansion Joint for important pipe lines. The split guide hood protects the slip from any external damage during construction and in operation guides the slip through its entire length of travel.

Write for Our Latest Bulletin

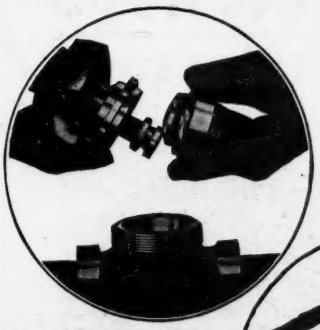
AMERICAN DISTRICT STEAM COMPANY

NORTH TONAWANDA, N.Y.

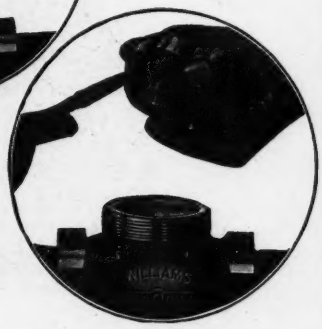
OVER FIFTY YEARS IN BUSINESS

Use VULCODISC

for trouble-free valve jobs

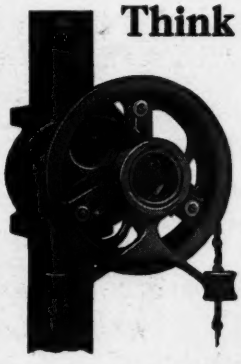


In renewing the disc, note how easily and quickly the Vulcodisc Jiffy Disc Holder slips off the stem head. Only the disc lock nut to remove and the old disc is off and replaced in a jiffy.



Dense without being brittle—tough, yet resilient, Vulcodisc will not swell, warp or soften — in fact its absorption is less than 1 per cent. . . That is why an old Vulcodisc comes out of the disc Holder as easily as a new one goes in. No need for hammer and chisel to cut the disc out in pieces—distorting and disfiguring the holder.
Write for descriptive bulletin.

THE D. T. WILLIAMS VALVE CO.
Cincinnati, Ohio



Think of the TIME You'll Save

with Babbitt Sprocket Rims on all your "high-up" valves. No need of keeping a long, cumbersome ladder always on hand just to close a valve.

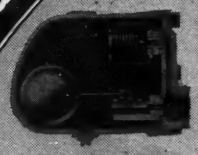
Babbitt Rims give you instant and positive control of overhead valves from the floor —save time, steam and accidents. Adjustable to any valve, easily attached and low in cost. Don't delay. Get your Babbitt Rims now! Complete information on request.

BABBITT STEAM SPECIALTY CO.
New Bedford, Mass., U. S. A.

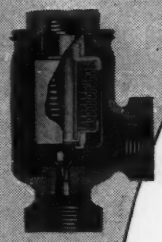
Babbitt
—Adjustable—
SPROCKET RIM
with Chain Guide

Modernize Your Heating System

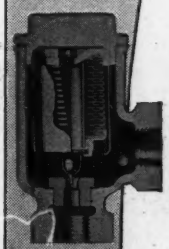
Radiator Trap, 0-25 lbs.



Float-Thermostatic Trap, 0-200 lbs.



Steam Trap 9-2, 0-125 lbs.



Steam Trap 9-200, 0-200 lbs.

Look over your steam traps to see if they are leaking live steam. An 1/8" leak in one trap wastes $30.30 per month.

Also note whether there are any untrapped points where condensation collects—for a 3/4" untrapped steam pipe wastes 820 lbs. of coal every 24 hours.

If you find any such conditions, you can effect a large fuel saving by installing Sarco Steam Traps at those points. Frequently they have saved 20 to 50 per cent of the steam previously used.

Sarco Steam Traps cost so little that it is usually cheaper to install new Sarco Traps than to repair the old obsolete traps.

To prove to you that Sarco Traps will save you money we'll send one on 30 days' free trial. Write for particulars and catalog B-95.

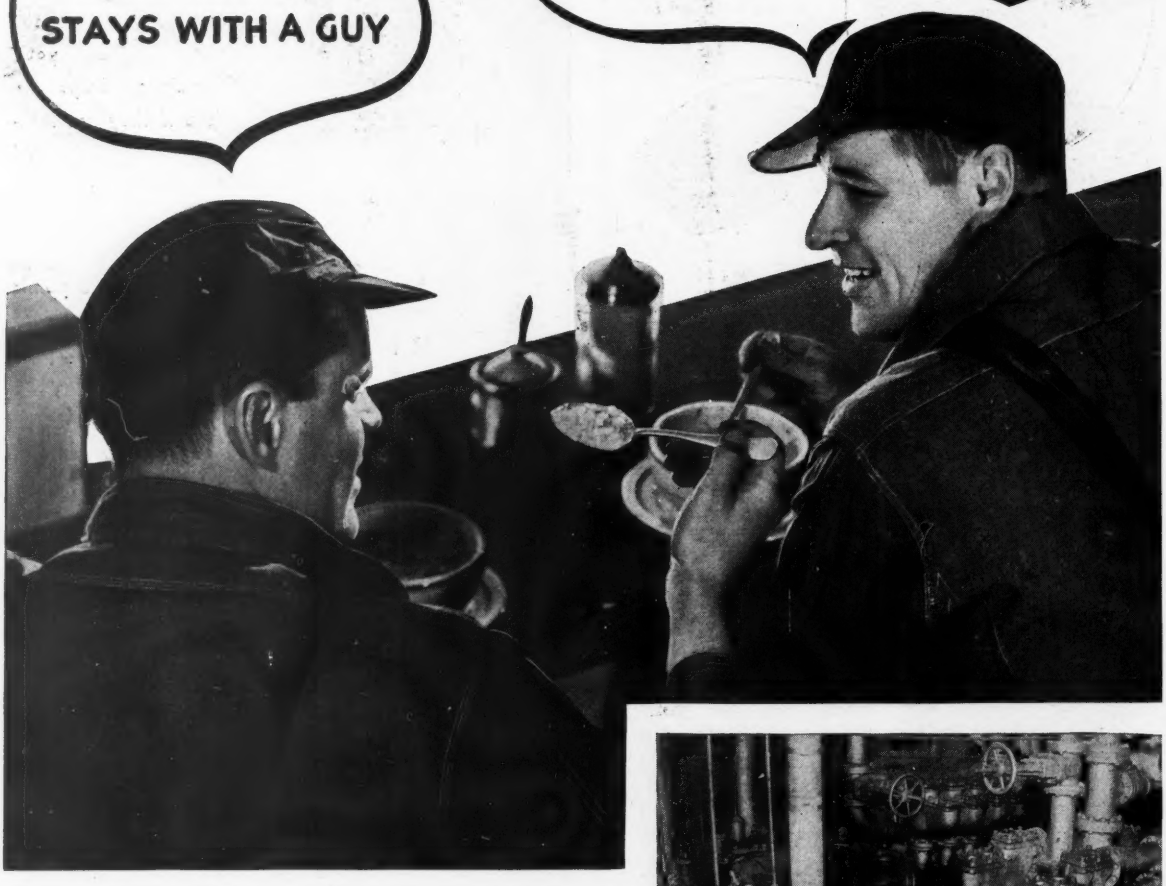
SARCO CO., INC.
183 MADISON AVENUE
NEW YORK, N. Y.

Branches in Principal Cities
SARCO CANADA LIMITED
FEDERAL BUILDING
TORONTO, ONTARIO, CANADA

SARCO STEAM TRAPS

YOU KNOW, JAKE, A QUAKER OATS BREAKFAST STAYS WITH A GUY

SURE IT DOES . . . REMINDS ME OF THOSE **MONEL METAL RODS** IN OUR BOILER FEED PUMPS



That's it exactly . . . Monel Metal stays with you.

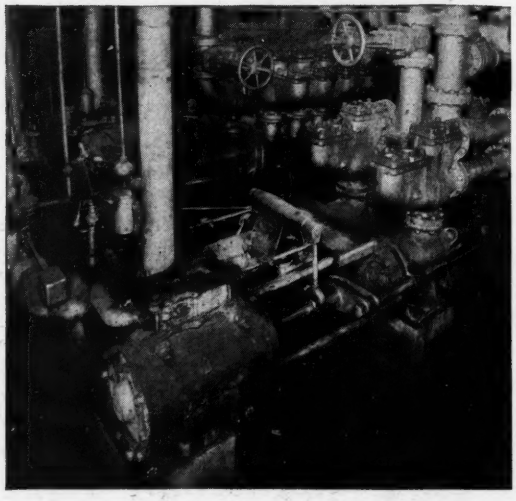
The photographic view at the right (in the boiler room of the Quaker Oats plant in Akron, Ohio) is an example.

The pump in the foreground went into service five years ago. A year later, the steel piston rods were replaced with rods made of MONEL METAL.

Result—no trouble of any kind since; nothing but perfect service.

Not only this . . . the engineers estimate these Monel Metal rods to be good for at least 8 to 10 years more.

If you want to get rid of pump-rod replacements, specify Monel Metal pump rods. Write for prices, sizes and simple machining instructions.

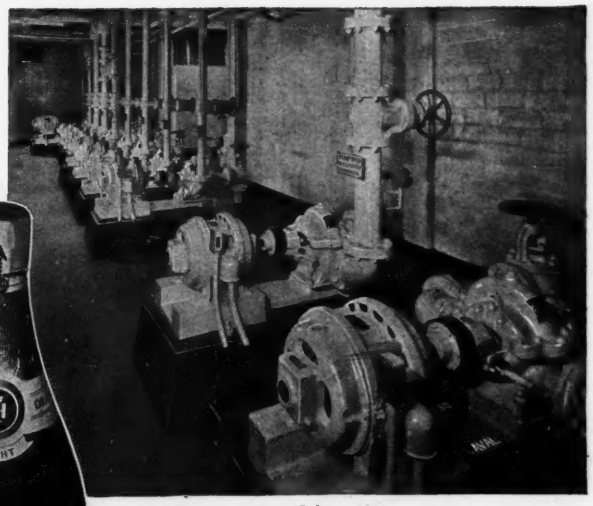


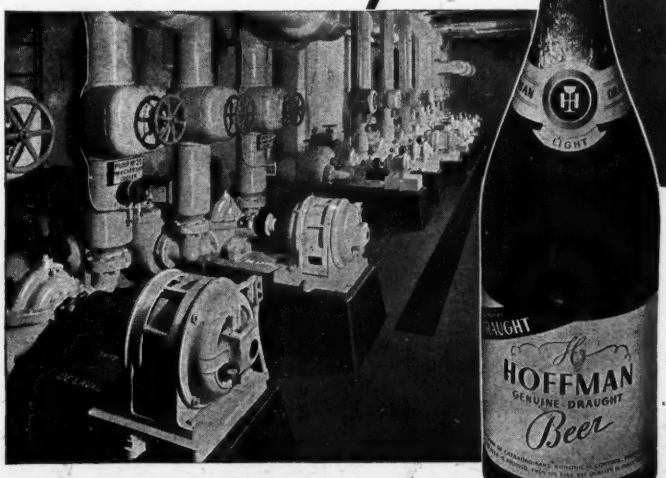
• • •

THE INTERNATIONAL NICKEL COMPANY, INC.
67 WALL STREET NEW YORK, N. Y.

Monel Metal is a registered trade-mark applied to an alloy containing approximately two-thirds Nickel and one-third copper. Monel Metal is mined, smelted, refined, rolled and marketed solely by International Nickel.

DE LAVAL *Pumps*



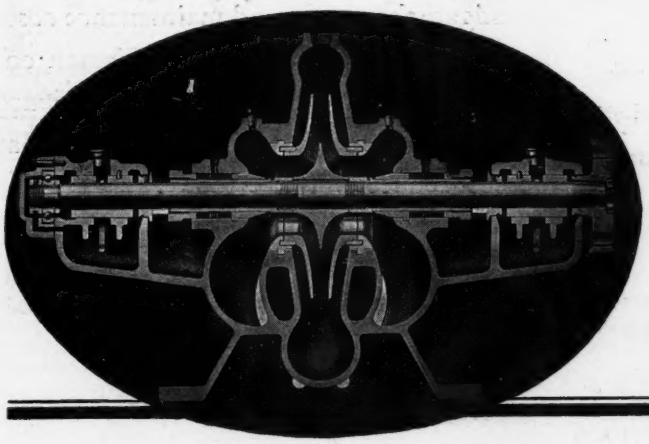


for the "DRAUGHT BEER IN BOTTLES" *Brewery*

THE new brewery of the Hoffman Beverage Company, Newark, New Jersey, making use of what is known as the Nathan System of brewing and certain other features devised by their own technical staff, is producing beer that can be bottled successfully on a commercial scale without pasteurizing. The superior palatability characteristic of the best draught beer is thus retained. All equipment in this plant is of modern and improved design, especially selected for absolute sanitation and production control.

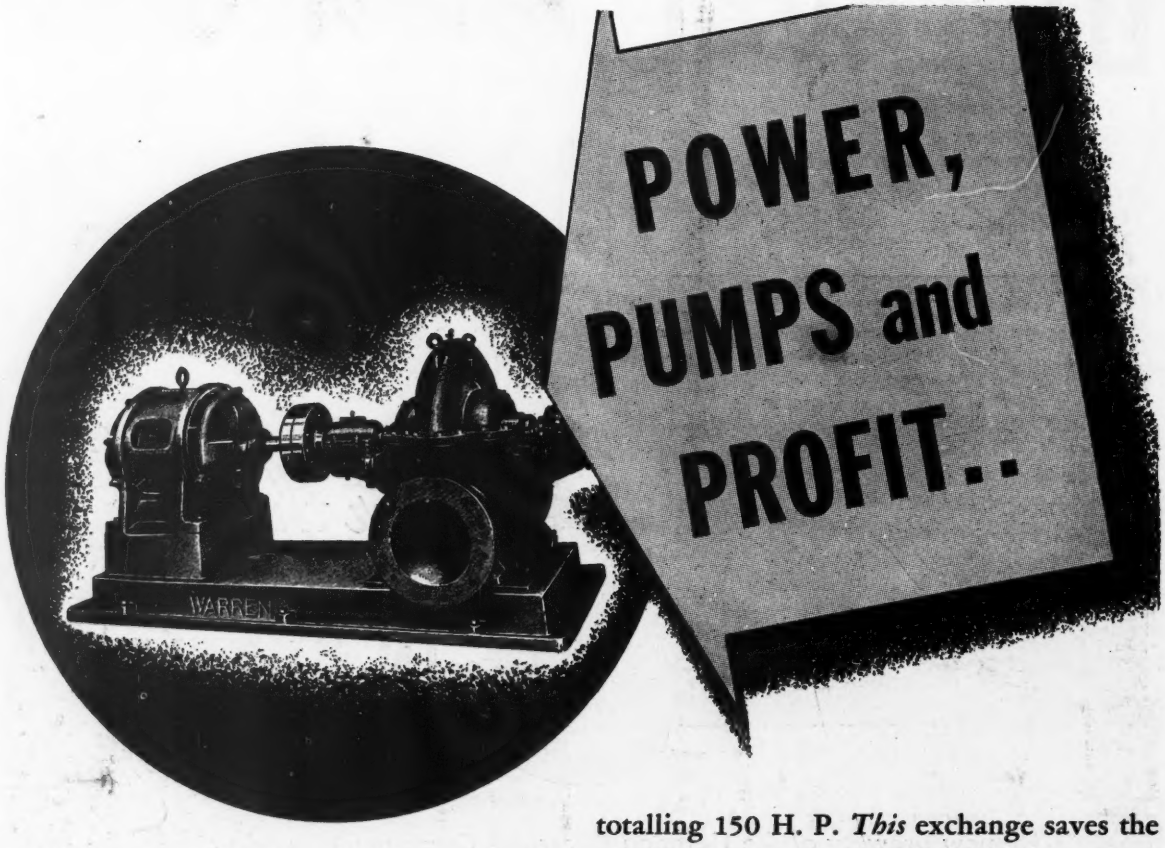
Eighteen De Laval Centrifugal Pumps are installed, nine of those shown in the photograph at the left handling alcoholic cooling liquid and the remainder water.

That the De Laval engineers have done their part in improving equipment for American industries is shown in our recently printed pamphlet "Sustained Efficiencies and Low Maintenance Costs of De Laval Centrifugal Pumps", in which remarkable progress in centrifugal pump design, whereby cost of operation is substantially reduced, is pointed out. A copy will be sent upon request.



DE LAVAL
STEAM TURBINE CO.
TRENTON NEW JERSEY

3179



Have you checked your pumps recently? If even one or two of your pumps are *power-hungry* they may be wasting *thousands of dollars a year.*

No exaggeration . . . but a fact that needs serious consideration, investigation, action. Many companies who *have* checked their pumps periodically have saved money. One operating superintendent, after an examination of his pumps, replaced two of them with *one* efficient Warren centrifugal—at an estimated saving of $500 a month. Another company replaced several pumps totalling 375 H. P. with *two* Warren centrifugals totalling 150 H. P. *This* exchange saves the company more than $8000 a year.

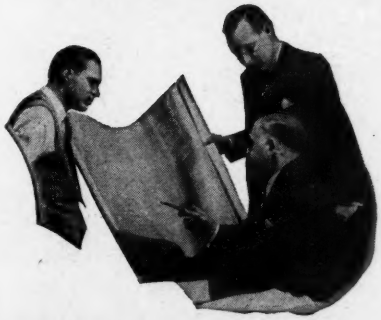
These records—and many others prove beyond question the dollar-saving, dollar-making value of Warren pumps for every industrial application. In every detail of design and construction, Warren pumps have been designed to give *lowest pumping cost per year—year after year.*

Investigate the power and maintenance costs of every one of *your* pumps. A Warren engineer will be glad to help. His experience will help you separate the cost-boosters from the cost-reducers. Write today.

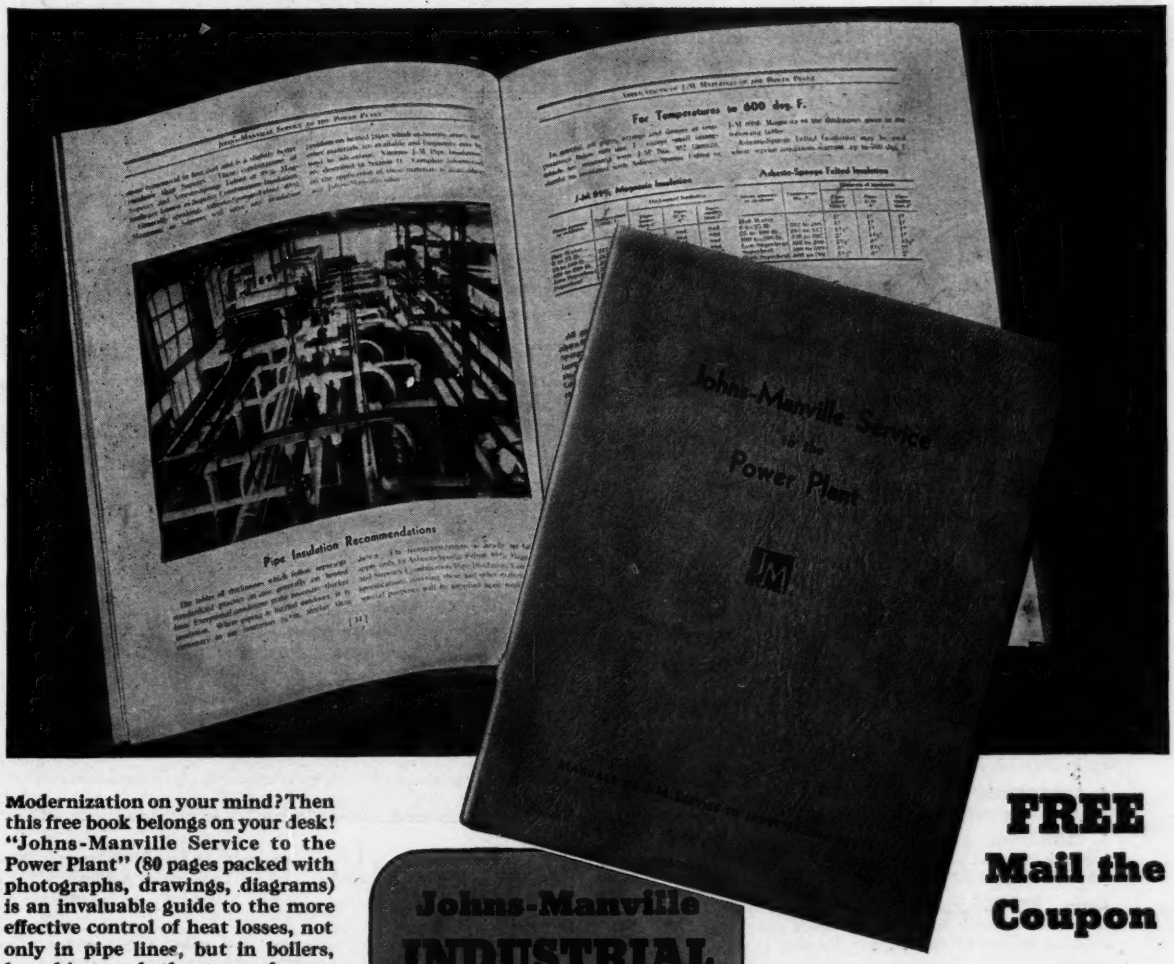
WARREN STEAM PUMP CO., INC.
WARREN, MASSACHUSETTS

2045

Power Plant Modernizers



You need these Complete Insulation recommendations



Modernization on your mind? Then this free book belongs on your desk! "Johns-Manville Service to the Power Plant" (80 pages packed with photographs, drawings, diagrams) is an invaluable guide to the more effective control of heat losses, not only in pipe lines, but in boilers, breechings and other types of power plant equipment.

Discusses the complete line of J-M Insulating Materials (Brick, Blocks, Sheets, Blankets, Pipe Insulation). Describes correct application for improved performance, increased capacity, reduced operating costs. Includes tables showing the most economical thicknesses of insulation for various operating conditions. Free. Mail the coupon.

Johns-Manville
INDUSTRIAL INSULATIONS
For every temperature condition from 400° F. below zero to 3000° F. above.
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FREE
Mail the Coupon

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22 East 40th Street, New York City
Send me a copy of "Johns-Manville Service to the Power Plant."

Name_____ **Title**_____

Firm Name_____

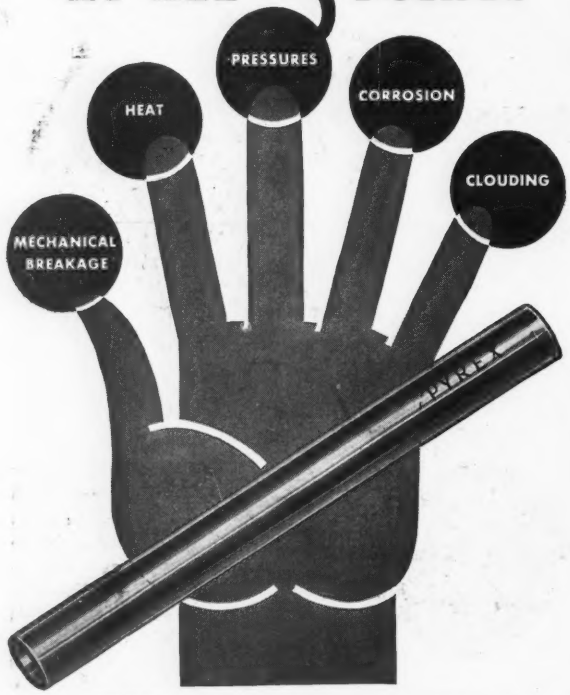
Address_____

City_____ **State**_____

PPE—12-35

GREATER RESISTANCE

AT ALL 5 POINTS



"PYREX" Brand Gauge Glasses will give you greater service at reduced cost, because they provide greater resistance to:

1. **MECHANICAL BREAKAGE:** They are the only Gauge Glasses that have the uniform dimensions assured by **machine-drawn** tubing. Their precision in size avoids dangerous strains, and saves time and breakage in installing.

2. **HEAT:** "PYREX" Gauge Glasses are made of heat-resistant "PYREX" Brand Glass. They are practically immune to breakage from heat, and from abrupt changes in temperature.

3. **PRESSURES:** Standard glasses available for pressures up to 500 lbs. . . . special glasses for higher pressures.

4. **CORROSION:** Hard, chemically stable "PYREX" Brand Glass resists deterioration by steam and water.

5. **CLOUDING:** Chemically resistant "PYREX" Gauge Glasses remain clear and unclouded during long periods of use.

Only "PYREX" Brand Gauge Glasses give you this five-fold economy and service. They are stocked by all leading mill and steam supply dealers.

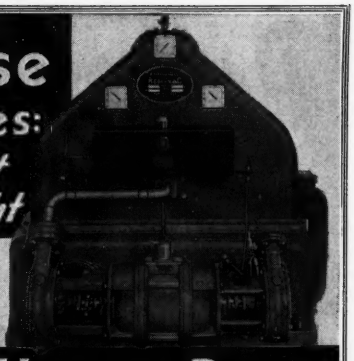
PYREX T.M. REG. U.S. PAT. OFF.

"PYREX" is a registered trade-mark and indicates manufacture by

CORNING GLASS WORKS
CORNING, N. Y.

Pyrex BRAND GAUGE GLASSES

No Close Clearances: They Won't "Freeze" Tight



Redi-Vac Heating Pumps

A LONG STEP FORWARD! In this Redi-Vac Heating Pump there are no close clearances—no metal to metal contacts between moving parts—nothing to "freeze" or rust together during periods of disuse.

The Redi-Vac keeps its high operating efficiency year after year. It requires no more attention than the modern centrifugal pump. It eliminates those expensive service charges at the start of the heating season. Our design is different—*Greatly Improved.* Write for Bulletin 441.

American Steam Pump Company, Battle Creek, Michigan

AMERICAN-MARSH

CENTRIFUGAL AND STEAM PUMPS

YOUR BOILERS NEED • • SOFT WATER • •

WE MANUFACTURE ALL SIZES AND TYPES OF WATER SOFTENERS & FILTERS

Cold Process: Intermittent, Continuous and Zeolite. Hot Process, Semi-Hot Process and specially designed Water Softeners.

Gravity, Pressure and Oil Removal Filters.

WRITE FOR INFORMATION AND BULLETINS.

WM. B. SCAIFE & SONS CO.

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You take no chances

in specifying Hercules Seamless Copper Floats. More than 624,000 in service offer convincing proof of the unfailing, low-cost service they deliver. Guaranteed for working pressures up to 350 lbs. Write us about your float problems.

HERCULES FLOAT WORKS
215 Franklin St., Springfield, Mass.

HERCULES

THE ORIGINAL
SEAMLESS COPPER FLOATS

For Easy, Simple, Speedy Analysis for CO_2, O_2 and CO.

SIMPLICITY and speed means a great deal in combustion work where conditions change rapidly. With the

HAYS FLUE GAS ANALYZER (Orsat)

any ordinary person can, with a little practice, determine the CO_2 content of a gas sample in 30 seconds, or make a complete test for CO_2, oxygen and carbon monoxide in from 3 to 4 minutes. This speed is made possible by the convenient features of the Hays design plus "Hays Technique", which utilizes these features to greater advantage.

Hays Analyzers are simpler and faster than the clumsy Orsats that are being used in many plants. They are offered in 14 ranges in 50cc. and 100cc. sizes, with a testing burette for every purpose. There are over 30,000 in service. Write today for catalog TSE-33.

For over a quarter of a century HAYS has stood for lower fuel bills as the result of following simple, sound, scientific methods. HAYS Instruments can help you put YOUR plant on the highest plane of combustion efficiency.

THE HAYS CORPORATION
MICHIGAN CITY, INDIANA

STYLE 300 "EDGE ON"

This new packing—very flexible and resilient has a metallic wearing face of anti-frictional babbitt foil forming an "Edge-On" contact with the rod. The metallic insert, fastened to a heat-resisting channel is provided with reservoirs of lubricant which flow freely to the face of the packing.

Recommend Uses—A resilient, anti-frictional, self-lubricating packing for air, steam, ammonia, gas and water services.

Complete information supplied on request.

CRANE PACKING COMPANY
1802 Cuyler Avenue, Chicago, Illinois
(Branch offices in Principal Cities)

"John Crane" Metallic Packing

★ TEST AIRETOOL CLEANERS

Air, steam or water driven

★ Airetools are made to meet every condition of tube or pipe incrustation encountered in power plant operation. Powerful motors equipped with latest type of self-feeding cutter heads and for return tubular boilers efficient vibrator heads. Sizes from ⅝" to 20" diameter — all made from best materials, properly machined, heat treated and ground to slip fit. Clean thoroughly, swiftly and without the slightest danger of tube injury.

TEST AIRETOOLS at OUR RISK

So confident of Airetools are we that we are making this extraordinary offer: *Rip out the coupon below, checking your requirements, and we will send you, express prepaid, an Airetool Cleaner to suit your needs. Test it for 30 days and if you find that it does not do a better, quicker and more thorough job, return it at our expense and that ends the matter!*

Catalogue Sent Free Upon Request

THE AIRETOOL MFG. CO.
SPRINGFIELD, OHIO

FREE! 30-DAY TRIAL OFFER

THE AIRETOOL MFG. CO.,
4-D Shuey Bldg., Springfield, Ohio.

Ship us express prepaid,
☐ Cleaner complete.
☐ Cutter head only suitable for use checked below. We will test it for 30 days at no cost. If, at the end of the test period, it hasn't proved itself a faster and more thorough cleaner we will return it at your expense.

Name .....
Street .....
City ..... State .....

Check your Requirements: ☐ O-D Tubes ☐ Straight Tubes ☐ Curved Tubes ☐ Water Tube Boiler ☐ Return Tubular Boiler.

STURTEVANT INDUCED DRAFT FANS CHOSEN FOR 165,000 K.W. ADDITION

. . . TO RICHMOND STATION—PHILADELPHIA ELECTRIC CO.

Showing two of four Sturtevant Turbovane Induced Draft Fans, each rated 190,000 c.f.m., recently installed for 165,000 k.w. addition to Richmond Station of Philadelphia Electric Company. Addition designed and constructed by United Engineers and Constructors, Inc. in cooperation with engineers of Philadelphia Electric Company.

HIGH EFFICIENCY, reliable operation and rugged construction were the most essential requirements in selecting equipment...when Philadelphia Electric Company recently doubled the capacity of their Richmond Station. 165,000 K.W. capacity was installed in space originally provided to accommodate 50,000!

For induced draft, primary air, and pulverized coal mill service, the engineers chose 12 Sturtevant Turbovane Fans.

The four Sturtevant self-cleaning Induced Draft Fans are each rated 190,000 c.f.m. at 380°F. against 14.5 static pressure. Speed: 850 R.P.M. They serve two new Babcock & Wilcox 600,000 lb. per hour pulverized-coal-fired boilers.

Primary air fans (4) each have a capacity of 22,000 c.f.m. The four mill exhausters are each rated 13,000 c.f.m.

B. F. STURTEVANT CO., Hyde Park, Boston, Mass.
New York, N.Y., 420 Lexington Ave. Chicago, Ill., 400 N. Michigan Ave.
San Francisco, Cal., 681 Market St. *Branch Offices in Other Cities*

Sturtevant
REG. U.S. PAT. OFF.

DRAFT FANS · TURBINES · GEARS · ECONOMIZERS · AIR HEATERS

SEE WHAT SOLID SILVER CAN DO FOR YOU

SOLID SILVER main contacts give long service — they stand up under repeated operation.

SOLID SILVER main contacts eliminate high-resistance oxidation — reduce heating and assure accurate operation.

SOLID SILVER main contacts require less cleaning — less maintenance.

Complete lines of G-E air circuit breakers are available for all services, both a-c and d-c

WHEN you specify General Electric, the air circuit breaker with the solid silver main contacts, you get:

Better protection, lower maintenance—because the main contacts are solid silver—bars of silver welded to the copper.

Less overheating—because the current-carrying parts are not depended on for contact spring action.

Savings in space—because the designs are extremely compact.

Proved interrupting capacity—because the breakers have been tested under actual field conditions.

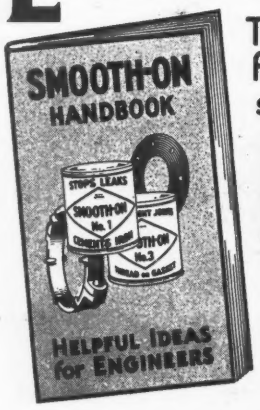
Accurate tripping at desired values — because all these breakers are individually calibrated.

Pleasing appearance—because of graceful design and the high-quality finish of the breaker parts.

These features are fundamental to the G-E line — backed by America's largest electrical manufacturer. General Electric, Schenectady, N. Y. 860-4

GENERAL ELECTRIC

ENGINEERS:-



This was written for you. May we send you a copy

FREE

Valuable suggestions on routine and emergency repair practice. Reliable advice on problems you may sometime face. Well indexed for quick reference.

THIS compact booklet contains over 100 diagrams with simple instructions which will enable you to avoid much overtime labor, worry and expense on such jobs as the following:

Making tight new and stopping leakage at old screwed or flanged joints . . . Repairing cracks in boiler shells, tube sheets and headers . . . Making tight joints and stopping leaks at seams, rivets, and manhole covers . . . Restoring contact faces of corroded flanges . . . Repairing leaks, cracks or porous spots in engine and pump cylinders . . . Stopping leaks in cracked fittings, valve bodies, centrifugal pump shells, fuel economizer headers, feed heaters, separators, condensers, steam kettles, etc. . . . Making emergency joints without fittings . . . Making unfinished iron joints, press-fit joints, bell-and-spigot joints without lead, etc. . . . Making hard-surfaced water and oil-proof machine foundations, floors, wheel pits, sumps, cooling ponds, filtration beds, underground storage tanks, etc.

You would be astonished at the speed, safety and ease of making Smooth-On repairs, and the dependability and permanence of all proper applications. Read this booklet, keep it, and be ready for the next emergency. Your first use of Smooth-On will prove it indispensable.

Get the book by mailing the coupon, and buy Smooth-On from your supply house or if necessary direct from us.

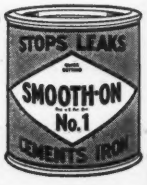
SMOOTH-ON MFG. CO., Dept. 31, 570 Communipaw Ave., Jersey City, N. J.
Please send copy of the SMOOTH-ON HANDBOOK.

Name .....

Address .....

.....

12-35 .....

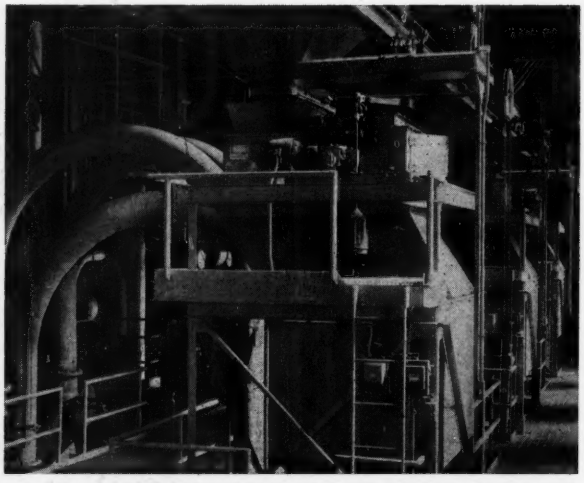


Do it with **SMOOTH-ON**

Are You Feeding Coal BLINDFOLDED?

Coal is by far the biggest single item in the cost of producing power. Can you afford longer to guess about the amounts of coal consumed per day, per week or per year?

Richardson Automatic Scales will remove the blindfold from boiler operation. Accurately and continuously they weigh the coal to each boiler, thus furnishing basic records for checking boiler efficiencies and cutting down fuel bills.



Richardson Automatic Scales feeding coal to unit pulverizers in power plant of Hiram Walker & Sons, Inc., Peoria, Illinois

Follow the example of hundreds of other industrial plants and central stations, large and small, which keep their boilers "on test" all the time with dependable Richardson Automatic Coal Scales.

Richardson Automatic Scales weigh coal to stokers or to pulverizers and have ample reserve capacity to take care of extraordinary demands during peak loads. Write for new illustrated booklet No. 8132P. It points the way to better boiler control and lower power costs.

●

RICHARDSON SCALE COMPANY

Clifton, New Jersey

Atlanta Chicago Boston New York
Syracuse Philadelphia Cleveland
Wichita Minneapolis Los Angeles Omaha

Agents for Canada: Messrs. Peacock Brothers Limited, Montreal, Vancouver, Winnipeg, Sydney, Toronto, Calgary.

IT'S EASY TO STOP HEAT LEAKS WITH

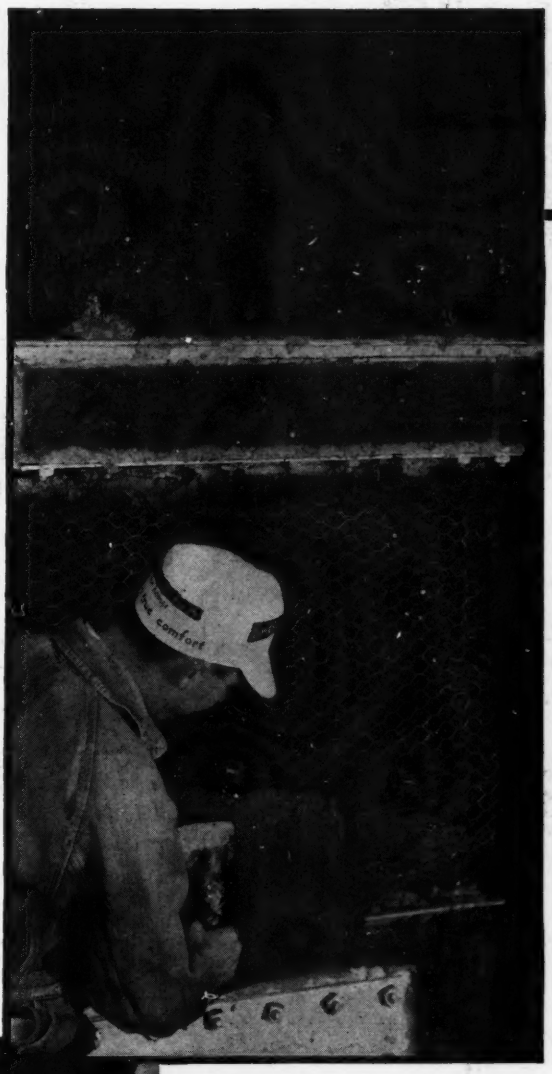
EAGLE "66"

Remarkable Plastic Insulation goes on with a trowel—efficient for temperatures as high as 1800° F.

● For low-cost, easy-to-apply, efficient insulation—specify Eagle "66." This plastic product is recommended wherever plant engineers are interested in high heat-saving efficiency.

Its base is Eagle Insulating Wool that contains thousands of tiny dead-air cells. This special "springy ball" construction remains intact after the insulation has been mixed with water, applied and dried—gives Eagle "66" its unsurpassed efficiency.

Before you do another insulating job, get a sample and all the facts about Eagle "66" Plastic Insulation. Use the coupon below.



Above: Costly heat waste stopped! Workman is trowelling second coat of Eagle "66" on air duct directly beneath preheater in nationally known power plant. Eagle "66" sticks to the surface, becoming an efficient one-piece insulation — with no seams or joints to open up and let heat out.

At left: "Spotting" of Eagle "66" Plastic Insulation on the lower side of expansion joint in induced air duct.

Eagle "66" Plastic Insulation offers you:

1. Insulating efficiency for temperatures as high as 1800° F.

2. Insulation that goes on quickly and easily with a trowel.

3. Strong, one-piece insulation that sticks to hot surfaces like glue. No joints or seams to open up and let out heat.

4. Insulation that is 100% reclaimable. Alterations, changes, repairs are easy and inexpensive to make.

5. Insulation that has 25% to 75% greater coverage than other plastic insulating materials — 50 square feet 1" thick per 100 lbs.

The Eagle-Picher Lead Company manufactures a complete line of power plant insulating materials, efficient for a full range of temperatures. See 40-page catalog in Sweet's for listing and specifications.

● The Eagle-Picher Lead Company, Dept. PP13 Cincinnati, Ohio. ● Please send me free sample and descriptive catalog of Eagle "66" Plastic Insulation.

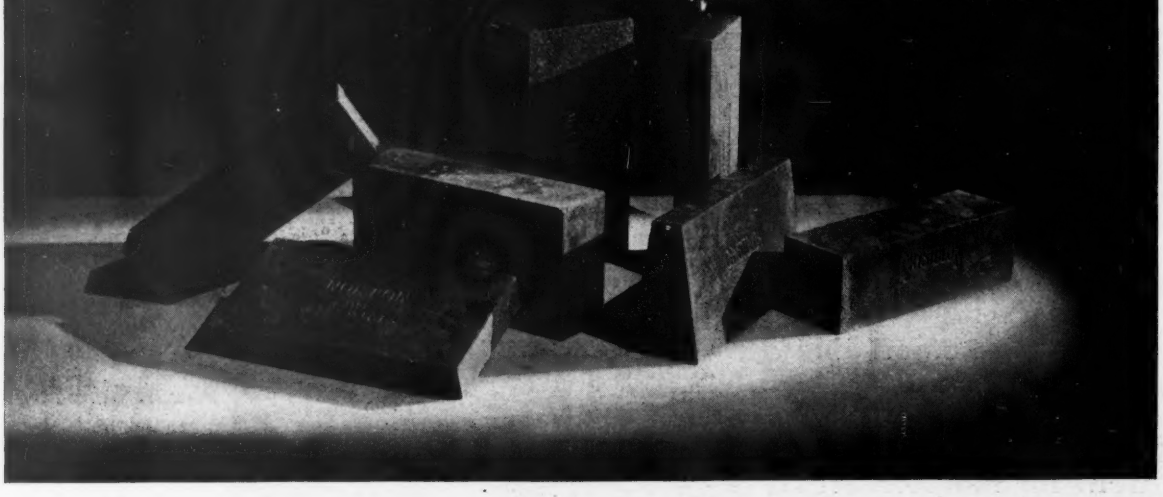
*Name*_____ *Company*_____

*Address*_____

*City*_____ *State*_____

2 Outstanding Features of this CRYSTOLON BRICK

Will Enable it to Cut Your Boiler Lining Costs



1. We know of no commercially available brick that has a higher percentage of silicon carbide.

2. The present Silicon Brick is so constructed as to give maximum resistance to slag penetration and to clinker adhesion.

A new catalog giving full information about Crystolon Brick will be sent on request.

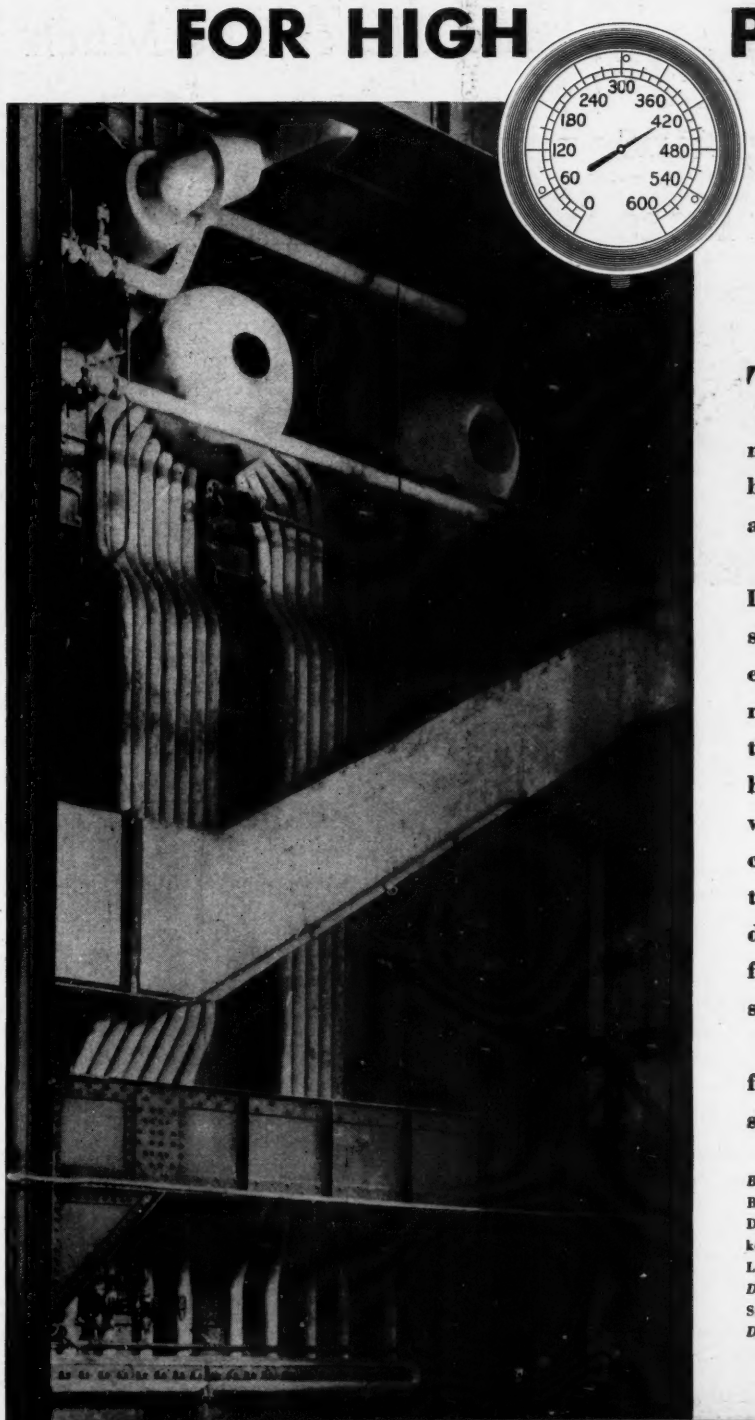
NORTON COMPANY

Worcester, Mass.

New York — Chicago — Cleveland

R-321

SEAMLESS BOILER DRUMS FOR HIGH PRESSURES



THE trend toward higher and higher steam pressures brings many problems for engineers to solve, but obtaining large boiler drums of ample strength is not among them.

Bethlehem Forged Seamless Boiler Drums can be made to handle any steam pressures now being used or even remotely in prospect, with a wide margin of safety. The strength of these drums is the strength of a single, homogeneous piece of thoroughly-worked steel, made by punching the center out of an ingot and forging it to shape. This process makes steel drums of the finest kind, completely free from seams or joints, and with safety that approaches the absolute.

Bethlehem has facilities to make forged seamless boiler drums in any size.

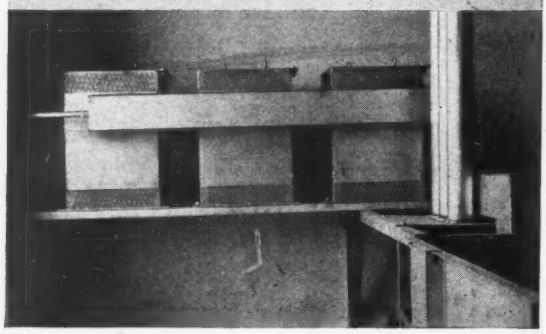
Bethlehem District Offices are located at **Atlanta, Baltimore, Boston, Bridgeport, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Houston, Indianapolis, Kansas City, Milwaukee, New York, Philadelphia, Pittsburgh, San Antonio, St. Louis, St. Paul, Washington, Wilkes-Barre, York.** ***Pacific Coast Distributer:*** **Pacific Coast Steel Corporation, San Francisco, Seattle, Los Angeles, Portland, Salt Lake City, Honolulu.** ***Export Distributor:*** **Bethlehem Steel Export Corporation, New York.**

BETHLEHEM STEEL COMPANY

GENERAL OFFICES: BETHLEHEM, PA.

How *to Eliminate* those long runs of 115-volt lines

Carry your modernization to completion by installing G-E air-cooled transformers



These three 20-kva transformers supply power at low voltage, where needed, from 460-volt circuits

YOU have replaced your long runs of line shafting, because individual or group motor drive has been found to be more efficient, less costly to operate and maintain, safer, and neater in appearance. Take the next step in progressive modernization. Eliminate the *electrical* "long-run line shaftings"— those inefficient long runs of 115-volt lines. Keep those runs at higher, more efficient voltage, and install small G-E air-cooled transformers to provide the lower voltage only where you need it.

Let us tell you how G-E transformers can help you to modernize profitably. Call the nearest G-E sales office, or address General Electric Company, Dept. 6B-201, Schenectady, New York.

GENERAL ELECTRIC COMPANY
Dept. 6B-201, Schenectady, N. Y.
Please send me a copy of your bulletin GEA-897E, on "Air-cooled Transformers for Lighting and Power Service."
NAME.....
COMPANY.....
ADDRESS.....
320-62

GENERAL ELECTRIC

A Full Tank Always and Never Too Much

CF

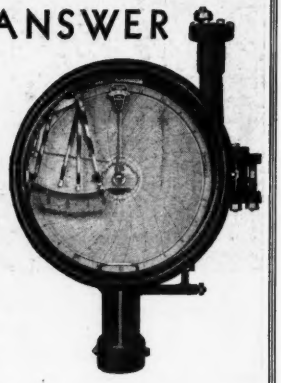
Fulton Altitude Governor

Full flow upward till the desired level is reached, full flow downward in case of emergency, to prevent flooding — that describes the movement of water on a single line to an elevated tank where the Fulton Tank or Altitude Governor is installed. Water can flow in either direction through the same valve, depending on whether pump pressure or tank pressure is greater. The result is a constant level maintained, economy and safety alike definitely provided. Ask for full description.

THE CHAPLIN-FULTON MFG. CO.
28-40 Penn Avenue **Pittsburgh, Pa.**

HERE'S THE ANSWER

Pressure Compensation



Startling indeed are the facts about what pressure variations can do to the accuracy of your flow meters. In steam flow, for example: at 100-lbs. pressure a 10-lb. variation means a 5% error! At a flow of 14,000 lbs. per hour, that's an error of 700 lbs. per hour. . . . But now, at reasonable cost, you can eliminate these dangerous errors with Foxboro **Pressure-Compensating** Flow Meters. Ask for all the facts.

NEW BULLETIN *On Request*

New Bulletin 200 shows many of the types and models of Foxboro Flow Meters. Ask for your copy.

FOXBORO
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THE COMPASS OF INDUSTRY

THE FOXBORO COMPANY
70 Neponset Avenue
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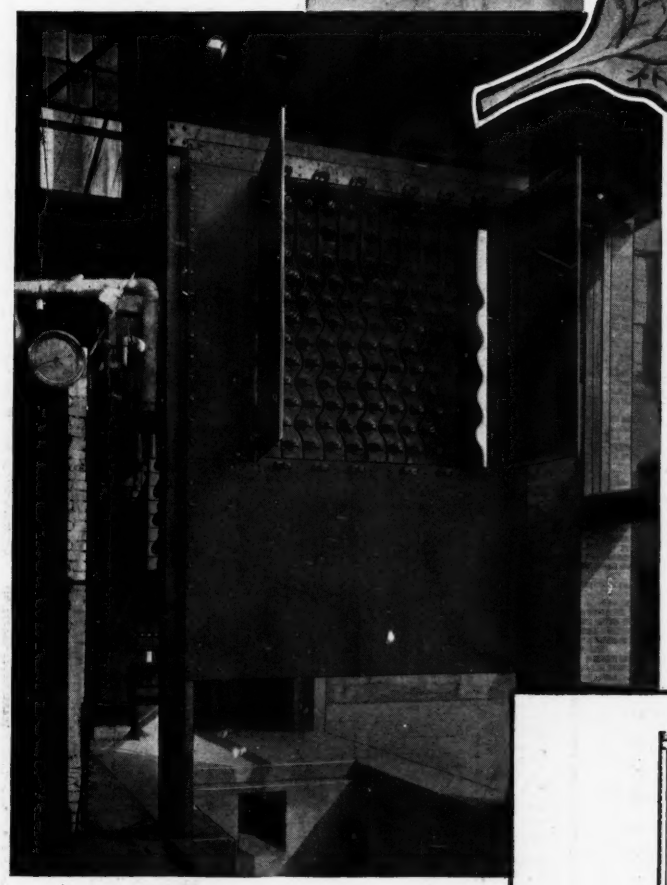
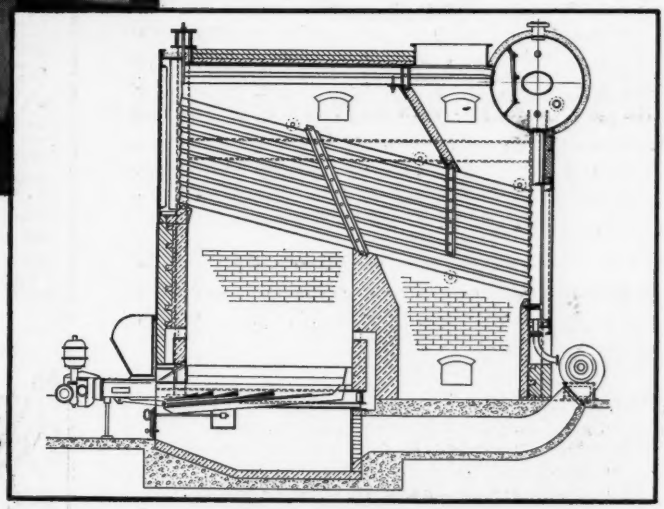


TOBACCO PLANTS

. . . which rehandle the leaf in processing it for the finished product, are among many industries turning to boiler plant modernization for dependable, rock-bottom-cost steam production.

The P. Lorillard Company, makers of Old Gold cigarettes, has installed in their Louisville plant the 253 horse power boiler illustrated, which is of the forged steel sectional header type.

Vogt boilers of many types offer a wide selection to meet the requirements of those who use steam for power or process.



Manufacturers of: Water Tube Boilers, Drop Forged Steel Valves and Fittings, Oil Refinery Equipment, Ice Making and Refrigerating Machinery, Heat Exchangers.

Vogt *forged steel* SECTIONAL HEADER BOILERS

Henry Vogt Machine Company
Incorporated
LOUISVILLE, KENTUCKY

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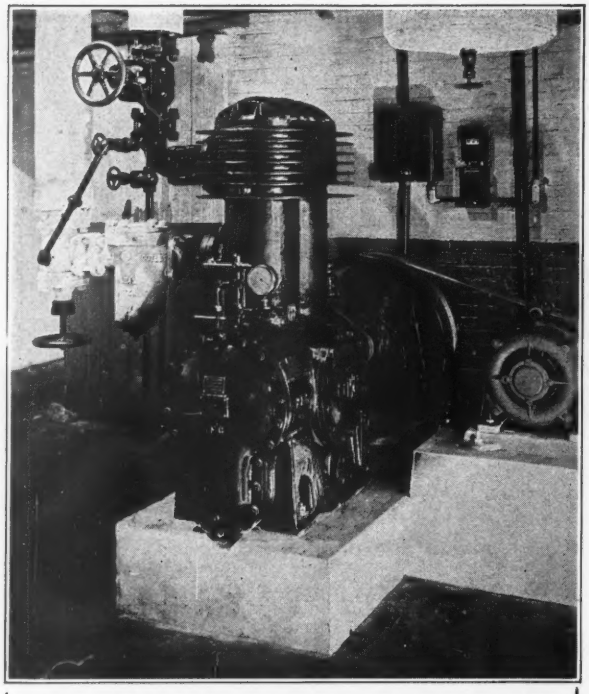
CINCINNATI · DALLAS · KANSAS CITY



8¾ by 6 Booster Ammonia Compressor in Service at the Hershey Creamery Company in Harrisburg, Pa., where it Maintains Temperatures of -40° to -50°F. for Quick Hardening Ice Cream.

FRICK

Booster Compressors

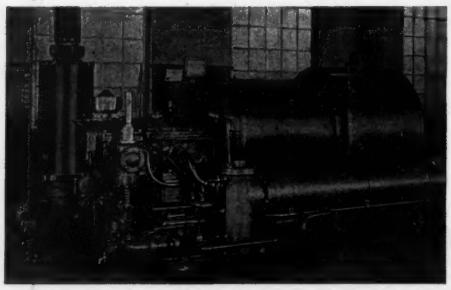
Make possible higher ammonia suction pressures for your main machines, and thus increase the efficiency of your compression system: savings up to 34% in horsepower. Temperatures of minus 40 to 50 degrees F., or even lower, maintained at least possible cost.

Get the benefits of low temperatures at low cost: investigate today. There's a Frick Branch or Distributor as close as your telephone.

WAYNESBORO, PENNA. U.S.A.

FRICK CO.

DEPENDABLE REFRIGERATION SINCE 1882



A Direct Vertical Steam Separator

Applied To A Turbine

Direct Separators are backed by an experience of 40 years and are made for removing water from steam and gases; oil and water from exhaust steam and compressed air and gases. 20,000 are in use in all styles and sizes, made of cast iron, semi-steel, cast steel, special noncorrosive metals and sheet steel welded construction. The smallest made—weight 10 lb., largest—25,000 lb. Efficiency proved by continuous tests and service. Send your problems and we may be able to save you expense in piping.

Expansion Joints in all styles and sizes made in various materials to meet conditions. Also, exhaust heads and flanged fittings.

The Direct Separator Co., Inc.

218 So. Geddes St., Syracuse, N. Y.

Detroit Stokers

DETROIT STOKER COMPANY
GENERAL MOTORS BUILDING
DETROIT, MICH.

FOR LOWER STEAM COSTS
FOR ALL OPERATING CONDITIONS
FOR ALL BOILERS
FOR ALL BITUMINOUS COALS

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STEEL-MILL FURNACE — BLOWER ROOM

SWITCHBOARD — GENERATOR ROOM

KILN MOTOR — SLURRY-FEED MOTOR

WATERWHEEL GOVERNORS — CONTROL PANEL

*It will pay you to tie them together with G-E Selsyns**

SOME OTHER PLACES WHERE YOU CAN USE THEM

For indicating the position of:

Gates or valves
Gas tanks
Hoists

For recording the changes in:

Gas-tank heights
Gate or valve openings

For the remote control of:

Adjustable-speed motors
Gates or valves
Diesel-engine governors

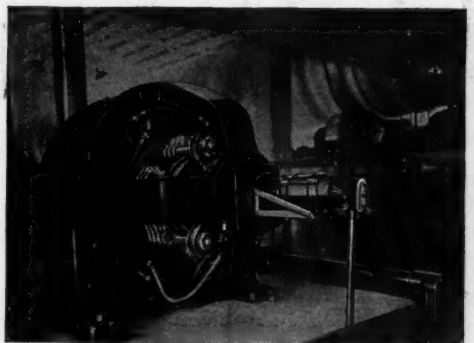
IT WILL PAY YOU

Because Selsyns have exceptionally long life, are economical in operation, require little or no maintenance, can be inexpensively installed, and do not require specially trained operators.

Because Selsyns, compared with ordinary systems, save valuable time, as they give immediate response to the signals transmitted.

Because their careful design permits them to maintain their accuracy indefinitely. They will give years of satisfactory service. General Electric, Schenectady, N.Y.

★ **Selsyn is a General Electric trademark for self-synchronous apparatus. Selsyn systems provide a flexible, inexpensive means of tying together apparatus that cannot be readily connected mechanically.**



G-E Selsyn transmitter mounted on a kiln motor as part of a kiln-feed synchronizing equipment

G-E Selsyn dual indicator used to indicate the gate-limit stop and gate position of the waterwheel governors furnished by the Woodward Governor Co. for Boulder Dam

G-E Selsyn transmitter in service on a screw-down-position indicator in a steel mill

090-1

GENERAL ELECTRIC

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Shell Oil Company
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Peter Cailler Kohler Chocolate Co.

. . . who with many others have recently placed orders with us.

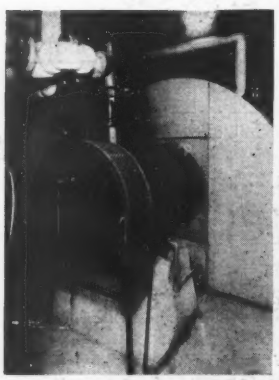
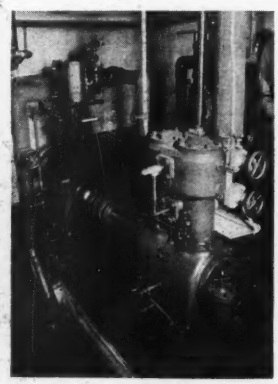
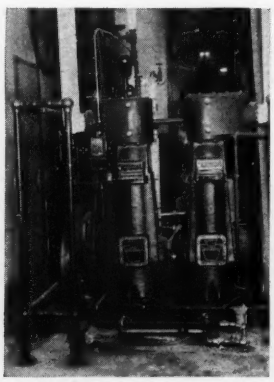
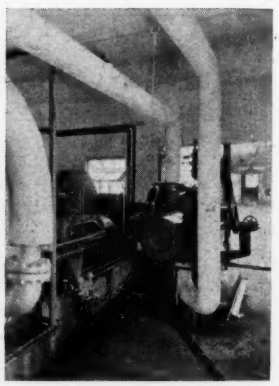
TROY-ENGBERG STEAM ENGINES Bought to give Lowest Cost Power Thru By-Product Power

It is significant that the engineers for these companies selected or accepted the modern Troy-Engberg Steam Engine for driving stokers, fans, compressors, pumps and exhausters. In their opinion, the Troy-Engberg Engine would provide maximum By-Product Power savings for the specific conditions involved. Power costs would be lowest.

Some other features of Troy-Engberg Steam Engines in addition to substantial By-Product Power savings are: oil-free exhaust; choice of flat or piston valves; variable eccentric adjustable while engine is running; high-starting torque; no long warming-up period required; "watershed" attachment on vertical engines for keeping condensate out of the oil; no oil leakage; low maintenance with elimination of "shopping" when making repairs.

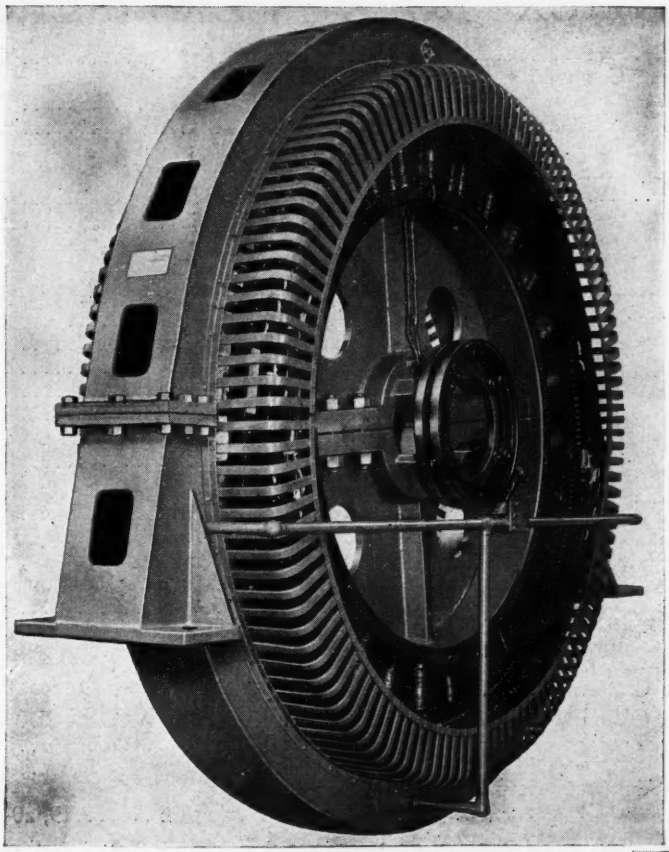
No doubt you use steam in your plant somewhere for heating or processing. Why not ask for our booklet telling about the definite savings companies like yours are making by using Troy-Engberg Engines?

TROY ENGINE & MACHINE COMPANY
806 RAILROAD AVE., TROY, PA.

TROY-ENGBERG

HORIZONTAL AND VERTICAL STEAM ENGINES • A. C. & D. C. GENERATING SETS



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● **Whatever your requirements for generators are ... a-c or d-c, large or small, standard machines or special ... Allis-Chalmers can meet them. The experience of Allis-Chalmers in building generators of every type, for steam and internal combustion engine drive, in all sizes, extends over a period of more than forty years. Continued electrical and mechanical improvement, together with constant testing and experimentation have brought the design and workmanship of Allis-Chalmers generators to a high degree of perfection.**

● **Allis-Chalmers also builds exciters, switchboards, instrument and metering transformers, generator voltage regulators (rocking contact type), metal-clad switchgear, pumps for water supply, and motors of all types for the Diesel power plant. Power and distribution transformers and automatic feeder voltage regulators are built for the distribution system.**

Above—Bracket Bearing A-C Generator
Below—Bracket Bearing D-C Generator

ALLIS-CHALMERS
Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, U.S.A.

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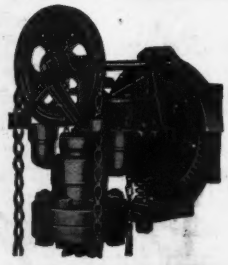
HOW MUCH IS IT COSTING you to maintain the SOOT CLEANER ELEMENTS in the HIGH TEMPERATURE positions of your boilers? Here is an element sold with an 18 MONTHS SPECIAL UNQUALIFIED SERVICE GUARANTEE. COST MORE? Yes, but WHAT SERVICE LIFE!



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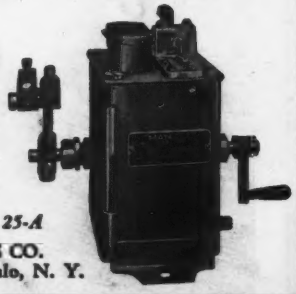
FIRST QUALITY IN DESIGN, WORKMANSHIP AND MATERIAL. Back of this IMPROVED SOOT CLEANER HEAD lies years of study to make it trouble free and give dependable service day after day. Analyze before you buy as cheap imitations may be offered . . . . . .

THE BAYER COMPANY
4065 Park Ave. St. Louis, U. S. A.

MANZEL FORCE FEED LUBRICATORS

Model "25"

"Manzel" positive, accurate lubrication enables you to get 100% performance from your machines. The new Model "25" lubricator has several exclusive features. It is ideal for lubricating cylinders and bearings.



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327 Babcock St. Buffalo, N. Y.

Let BURT show you how to provide better working conditions, speed up production, stop waste, and cut operating costs.
Write for helpful bulletins.

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